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TRAIN LIGHTING ON THE MIDLAND RAILWAY.

THE train which has just been started on the Midland railway, running between London and Manchester and Liverpool, is one of two main line trains which the company has determined to fit with the electric light in order to test the applicability of this system to railway working in general.

The two trains are fitted on different principles, one (the Manchester train) on what is known as the "parallel" system, the other on what may be regarded as the "series" method. The dynamo in each instance is placed in the guard's van, and is driven from the wheels of that vehicle. Each carriage in the train is provided with accumulators (which are placed in a box under the seat in one of the compartments) of sufficient capacity to, when fairly charged, ensure a light for ten hours. Each compartment is provided with two incandescent lights of 5 or 8 candle-power. Certain of the vehicles, in order to test the value of such a disposition of the light, have the lamps arranged between the divisions of the compartments, so that the light is thrown forward on the book or paper, whichever it may be, which the passenger is reading. In this case, although no more lights are employed, each compartment appears to possess four lights. This is an innovation which no doubt will be very acceptable to readers. These lights are so covered over with round opaque glass shields that a soft, even light is thrown forward. The height of the light is so arranged that the maximum effect is obtained, and the result is very pleasing, the compartment being thus excellently lighted in general, whilst the object held in the hands is particularly well illuminated, and reading can be indulged in with extreme facility. In the other vehicles the lights are placed in the roof, one on each side of the ordinary oil lamp in the centre. In the roomy guard's vans three lights are placed.

The "couplings" between the vehicles are arranged within a metal case, analogous to that of the automatic air brake, the idea being that a man acquainted with the method of coupling up a brake will readily understand how to complete the electrical coupling; indeed, it is impossible for him to make a mistake, for there is only one way of putting it together. Within the coupling the electrical parts are so arranged that the necessary connections between the wires take place in joining it together, and, as may be imagined, with respect to the parallel system, the several parts are required to be of a suitable capacity to carry sufficient current, hence the coupling in the parallel system is larger than that of the series; both, however, are based upon the same principle. With the parallel system the coupling itself is so arranged that on any vehicle becoming separated from the rest, either intentionally or otherwise, the light is immediately turned on, and on the coupling being placed on a dummy duplicate, provided for that purpose at the end of each vehicle, the light is again turned off, the coupling, in fact, acts the part of a switch automatically. These couplings have been specially designed by Mr. W. E. Langdon, the superintendent of telegraphs of the Midland railway, and were made at the company's works at Derby, where the trains were entirely fitted up by the company's own staff under the direction of Mr. Langdon, who has devoted much time and thought to the success of this experiment.

The two trains mentioned, as well as one which it is understood is being fitted for local traffic between Manchester and Stockport, are the outcome of a desire of the directors of the Midland Railway to provide an improved form of light for passengers by that company's system. For some time past, we understand, the directors of the Midland Railway have had the question under their careful consideration. Every hope is expressed that in electricity will be found that which is required. At the same time, it will readily be acknowledged that in attempting to solve the question in the manner dealt with on the Midland Railway, many difficulties must have presented themselves, and no doubt many remain which will yet have to be overcome. Of these the Midland Railway officials would appear to be sensible, and it is desired on their part that what is being done may be regarded purely as an experiment. From personal observation, however, of the train now running between London and Liverpool *viâ* Manchester, this experiment must be considered as eminently successful as to its working, and also as to the interest taken in it by the travelling public, who have already expressed approval of the new arrangement. This special train consists of two portions, which are complete until the arrival of the train at Manchester, where the hind part containing the guard's van with the dynamo and a number of vehicles proceeds to Liverpool, leaving the remaining half at Manchester. This train contains Pullman cars which are not fitted with the electric light, but the continuity of the arrangement is kept up by a cable passing under the cars, terminating at each end with a coupling to join on to the next vehicle. The Liverpool section of the train has at present the lights arranged as described between the compartments. The value of the accumulators is shown in the Manchester section, which deprived of the dynamo, would otherwise on the return journey be devoid of light. Both sections leave independently on the following morning for Derby, where they are coupled together, and when on the road the dynamo is at once set to work to recharge the accumulators. The arrangements are very complete, and the lighting is most satisfactory. When the series train starts we shall take the opportunity of comparing its working with that of the present one on the "parallel" system.

A REMARKABLE Board of Trade inquiry has just been held in Dublin by Major Marindin; the subject being an application by the Alliance and Dublin Consumers' Gas Company for permission to open certain streets in the best part of Dublin for the purpose of laying electric light cables intended for the supply of private houses in the district. The Company contend that they are entitled to supply electric lighting by the terms of their Acts; and that they, therefore, do not require a licence or Provisional Order under the Electric Lighting Acts, but only the sanction for opening the roads. The Inspector was very careful at the commencement of the proceedings to define the scope of his duty, which is not to pronounce upon the validity of the interpretation put by the petitioners upon the terms of their Acts; but, assuming that they have the rights they claim, to ascertain whether it is desirable that they should exercise it. The Company is opposed, of course, by the Corporation of Dublin, who have taken steps to obtain a licence under the Electric Lighting Act, with the avowed object of checkmating the Gas Company. As the report of the Inspector is not yet published, it is impossible to say what may be the result of the inquiry. The Company is actually exercising in a small way what they regard as their powers of supplying electric light, and admit a loss of £100 a year by it, because of the small number of consumers. For this reason, among others, the Company seeks to extend its business, and to substitute costly underground cables for the cheap overhead wires by means of which they have been hitherto supplying current. Whatever may be the end of this inquiry, the *Journal of Gas Lighting* takes the opportunity of stating that it has no sympathy with the view taken by the directors of the company of their duty in this matter, and believes them to be wrong in their law, and ill-advised in their policy.

THE fact that the Demerara-Trinidad cable is reported to be "working fitfully"—indeed, was on several recent occasions declared "interrupted"—again brings to the front with renewed emphasis the exceedingly flimsy and faulty telegraphic communication with the outside world. The *Demerara Daily Chronicle* has written on the subject time after time; and it is, therefore, with some gratification that it notices the Commercial Committee of the Royal Agricultural and Commercial Society have been taking the matter in hand. At the last meeting of the society it was reported that the committee had considered Mr. Vyle's paper on this subject in last June's number of *Timehri*, and also an offer from the West India and Panama Telegraph Company to lay a duplicate cable to Trinidad on receipt of an additional subsidy of £1,500 per annum for 10 years. In other words, it was asked that the present subsidy of £4,500 be increased to £6,000 per annum; and this although it must be perfectly clear that the traffic is not more than half enough to keep a single cable going. Now, since the Imperial Government has taken over and are working the cables between France, Belgium, Holland and England, and also purpose connecting Halifax and Bermuda, the question occurs to our contemporary whether this would not be an opportune moment to urge upon the home Government the recommendation adopted by the Royal Agricultural Society, viz., the advisability of "laying a cable through British territory from England to British Guiana." The sum of £6,000 annually from the colony of British Guiana—the amount to which it is asked that the present cable subsidy be increased—would pay the interest on a loan of a quarter of a million sterling, and if the other British West Indian Colonies contributed in proportion, and the home Government also did its share, there would be ample available funds to pay for the laying and maintenance of entirely new cable communication between Great Britain on one side of the Atlantic and Halifax on the other, British Guiana being the point of a triangular connection which would take up Bermuda and the other islands *en route*.

THERE are now possibilities of the commercial success of electric lighting for Bristol. A few days ago a representative of the *Western Daily Press* had an interview with Mr. Massingham, and the result of this meeting, combined with the recent visit of Mr. W. H. Preece to the town, leads our contemporary to the conclusion that some action will shortly be taken to introduce the electric light on a large scale.

MR. GISBERT KAPP'S letter to the *Times* of 11th inst., commenting on Prof. Thompson's letter of the 1st inst. to the same journal, is a somewhat severe censure on that gentleman's criticisms of Major Marindin's report to the Board of Trade anent the electric lighting of London, and bears out what we stated in an article in our issue of last week. It is, indeed, as Mr. Kapp says, amusing to note the very different view the worthy

Professor takes in this matter compared with his sweeping condemnation of the arguments brought forward by the United Telephone Company when fighting for what they (and the Law Courts) considered a perfectly legitimate monopoly. No doubt our readers will remember how strongly this was condemned by the Professor as antagonistic to all prospects of improvement and benefit to the public which would accrue under the auspices of healthy competition, &c., &c. Truly circumstances alter cases; and we cannot help thinking what keen good sense there was in a remark let drop in the course of coversation in our editorial room a few days since by a well-known occupant of a professorial chair of electro-technics, who said, "Once, and only once, since I accepted my present position have I, directly or indirectly, attached myself to any commercial undertaking, and that only for a very short time, and how thankful I was to find myself free from the bias and trammels that of necessity follow from such relationships."

A FORTNIGHT ago, when commenting on Mr. Mordey's paper on alternate current working, we observed that in his 1884 theory Dr. Hopkinson had not informed us how little or how much self-induction was necessary to control machines working in parallel. Dr. Hopkinson now points out, as will be seen from an abstract of the discussion on another page, that for obtaining direct control neither large nor small self-induction is essential, but that the power of control depends upon the relation which the self-induction, the number of cycles per second, and the resistance of the armature and leads bear to each other. He further observes that the relation which is best, and which he now gives, could have been determined from his equations of 1884, and that from the theory there given all the phenomena observed by Mr. Mordey could have been predicted. The recent experiments, instead of being at variance with, appear to afford a complete confirmation of Hopkinson's theory.

THE Atkinson gas engine, which figured so prominently in the recent motor trials of the Society of Arts, has been tested in America under the auspices of the Franklin Institute, and the conclusion to which the experiments lead is that James Atkinson's engine surpasses all preceding gas motors in simplicity, economy, perfection of regulation, and uniform steadiness of power, and is deserving of recognition by an award of the John Scott legacy premium and medal. This ought to put an end to the controversy which has been going on in the pages of an engineering contemporary on the respective merits of the Otto and Atkinson engines.

THE City of Berlin is far ahead of London in telephonic progress, there being 10,000 subscribers. The entire net of wires in the German capital has reached a length of 17,804 kilometres, and the average number of calls amount to 196,691 daily.

IN the twelfth edition of "Duncan's Manual of British and Foreign Tramway Companies" (Effingham Wilson), the compiler says: "Electrical traction is now within the region of practical politics, and I look for very considerable development in this direction during the coming year. Its success as a perfectly safe and specially economical motive power has been practically demonstrated, but for the moment the capital and general parliamentary powers of tramways, together with the pigheaded obstructiveness of local authorities, prevent its adoption upon anything approaching a large scale."

AT the meeting of the Continental Metropolitan Tramways Company, Limited, last week, Mr. Van Tromp, the chairman, said that he looked forward to a time when they should discover another mode of traction for tramways than by horse drawing, and expressed his opinion that electricity would be the motive power of the future. If they were able to apply electricity it would effect an enormous saving of expenditure; but the directors would accept no proposal except at the risk of the contractors themselves. He thought, however, that above all other places in the world, Paris was the place where electricity for such a purpose would be most useful. From these remarks the promoters of electric traction can clearly see the lines on which they must proceed when offering to substitute electricity for horses.

DURING the *fête* at the Paris Exhibition on the evening of June 1st, an electric search light was projected, by Monsieur Commelin, from Mr. Elwell's alkaline accumulator works at Argenteuil, upon the Eiffel Tower, distant, as the crow flies, about 10 miles. The current from the 10 kilog. cells, 70 in series, was 100 ampères, and the light was of sufficient power to be distinctly visible upon the north-west face of the tower. A series of signals were then exchanged with the operators of the search lights on the tower. The Commelin-Desmazures accumulator proves itself peculiarly well adapted for working search lights, on account, principally, of the powerful current which may be safely taken from it, combined with its characteristic variation in internal resistance.

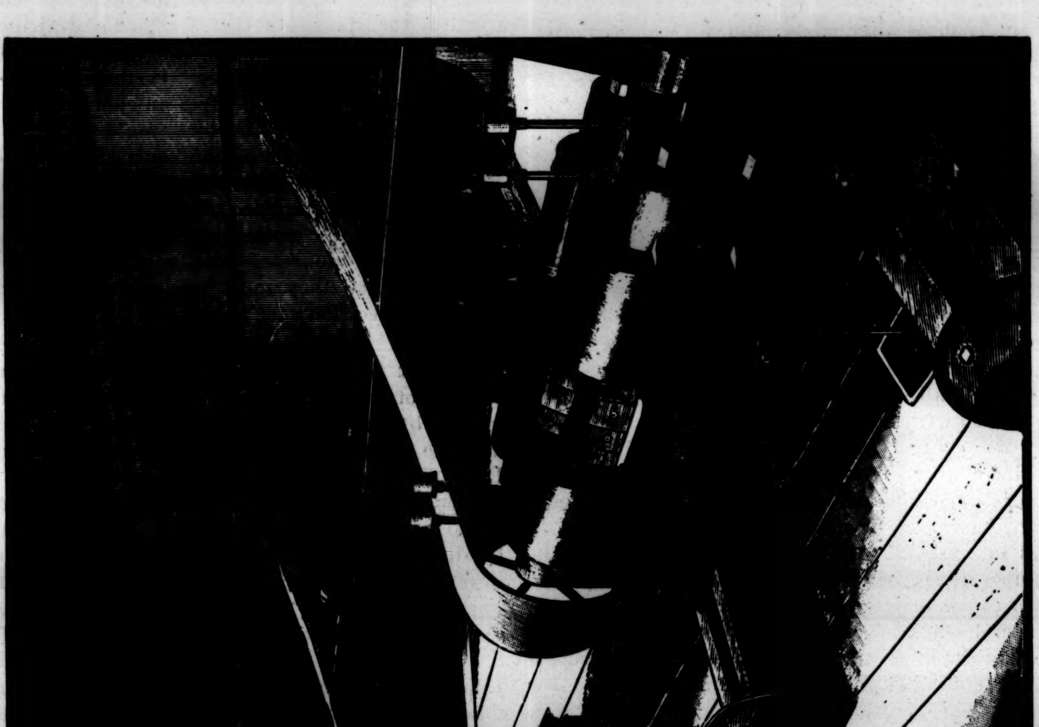
THE peculiar characteristic of exhibitions held in any part of the world is that on the opening day, and for two or three weeks afterwards, many of the stands for exhibits are unoccupied, but by degrees they assume a life-like appearance. The Spanish Exhibition is no exception to the rule, for on the opening day the main exhibition building contained but a small number of exhibits. With the exception of the lighting of the buildings and grounds, electrical engineers will find very little to interest them, since from a careful observation of the exhibits and a strict scrutiny of the official catalogue we have been unable to find anything of an electrical nature. This is certainly disappointing. Nevertheless, although electricity for lighting and power purposes is as yet not employed to any great extent in Spain, we naturally expected that at least two or three out of the small number of Spanish electrical companies would have participated in the exhibition. The electric lighting of the buildings and grounds is in the hands of the Gülcher Electric Lighting Company, Limited, which has a large number of arcs installed. On the opening night the light was extremely steady, there being no flickering whatever. The outside end of the main building opening into the grounds is illuminated by means of a large number of gas jets placed inside fairy lamps, and in the grounds are many oil fairy lamps and chinese lanterns. Several collections of Spanish ores, silver, copper, lead, antimony, &c., are on view, but there is little machinery to be seen, the principle exhibits being chemicals, wines, fine art, furniture, jewellery, porcelain, woods, &c.

ELECTRICAL POWER TRANSMISSION AT VIRGINIA CITY, NEVADA.

THE LARGEST INSTALLATION IN THE WORLD SUCCESSFULLY CARRIED OUT BY THE BRUSH ELECTRIC COMPANY, CLEVELAND, U.S.A.

"MORE power, economical power," has been now for several years the imperative demand of the owners of mining properties on the celebrated Comstock lode at Virginia City, Nevada. The problem has been to work the enormous quantities of low grade ore at a profit. Large sums have been expended in carrying water from streams in the neighbouring Sierra Nevada mountains for a distance of some 30 miles, to be utilised at the mines and mills on the Comstock. But this supply of water is limited and fickle, and by no means meets the demand. Operations have frequently been suspended on this account, causing great loss to the mine owners and hardship to the labourers dependent upon the active working of the ores.

The best engineering talent has been called to work on this vital problem of power supply, and new arrangements have been made for increasing the amount of water, but vast powers now within reasonable range are still running to waste, which the use of electricity alone can conserve.

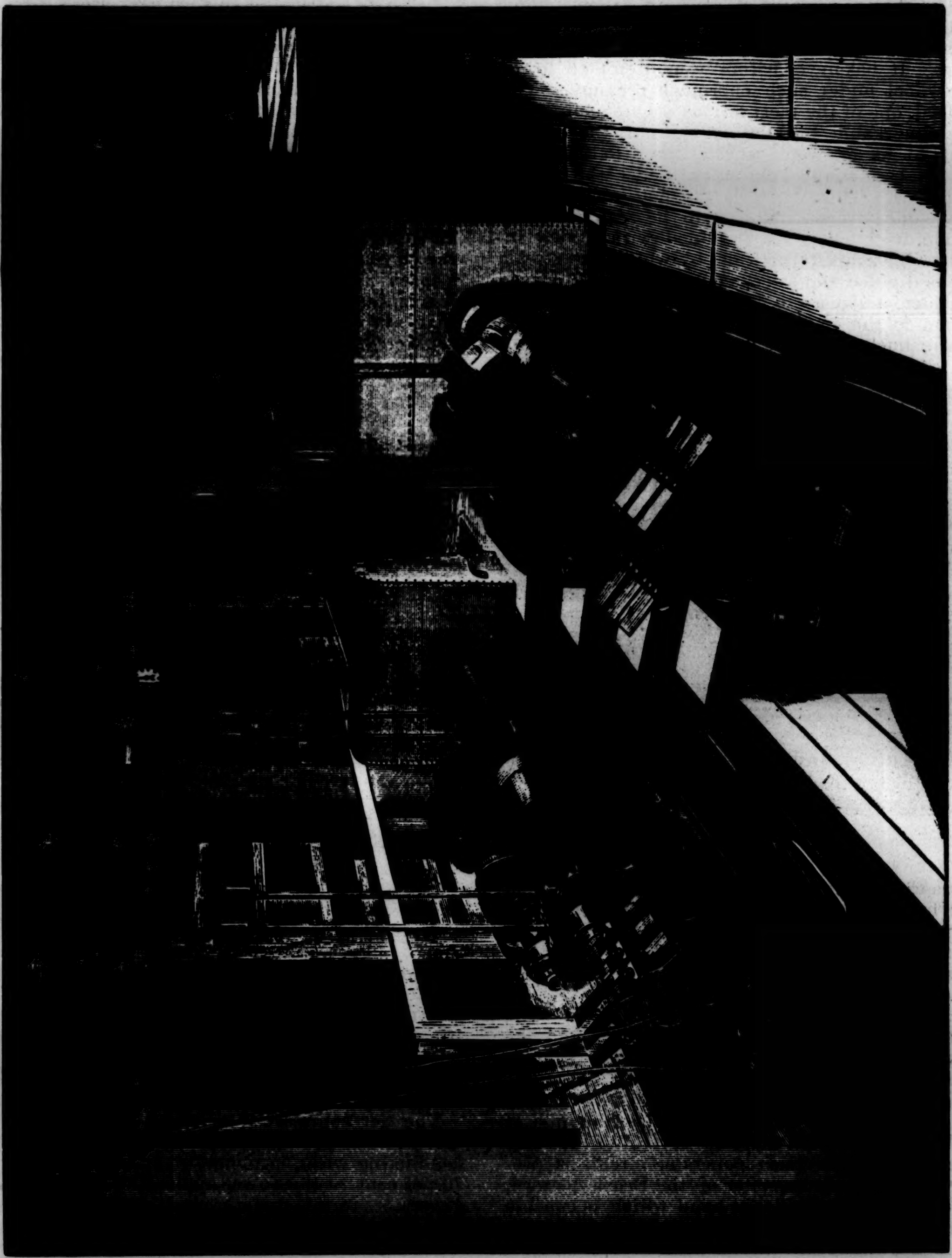


ELECTRIC MOTOR ROOM IN THE NEVADA STAMP MILL.

At the Stamp Mill of the Nevada Mill and Mining Company water power was obtained at the level of the mill from a reservoir on the side of the mountain. The mill contains 60 stamps, with their complement of pans, settlers, agitators, rock-breakers, &c. The water-power readily available was entirely inadequate for the operation of the mill.

The problem was submitted to the Brush Electric Company, of Cleveland, Ohio, through its agents, the

California Electric Light Company, of San Francisco. A solution was speedily offered, and the plans were accepted by the owners of the Nevada Mill and Chollar Mine. The shaft of the latter is close to the Stamp Mill. It was proposed to collect the waste water from the surface wheel at the mill, convey it in pipes to the shaft of the Chollar Mine, and thence down the shaft until a sufficient head should be obtained to produce the power required. The scheme was novel, and presented many difficulties. However, experts pronounced the plans feasible, and work was begun last winter.



UNDERGROUND POWER STATION AT THE 1,650 FOOT LEVEL OF THE CHOLLAR MINE, VIRGINIA CITY.

At the 1,650 feet level of the Chollar Mine a subterranean chamber was excavated out of solid porphyry, for the reception of the dynamo-electric generators and waterwheels. This chamber is 50 feet in length by 25 feet in width and 12 feet in height, clear of all timbers. From the tank containing the waste surface water two wrought iron pipes are led to the subterranean chamber, one 10 and one 8 inches in diameter. At the bottom of the shaft a Y unites these two pipes into a single one 14 inches in diameter, out of which six 6-inch pipes run to the nozzles of the waterwheels provided to drive the large Brush dynamo-electric generators.

The underground electrical station is of the most interesting character, and is shown in our illustrations. The large Brush primary generators, of which there are six, are adapted to the conditions by a few mechanical changes from the standard pattern. They are mounted on a heavy cast-iron base, and are provided with an extended shaft and outer bearing. On the armature shaft, and between two bearings, the Pelton wheel is mounted and enclosed in a water-tight cover. The cut of the generator is made from a photograph taken at the Brush Electric Company's Works at Cleveland, before shipment, and shows a pulley on the armature shaft, arranged for testing runs at the factory. The waterwheel is attached to the armature shaft at the place occupied by this pulley, and an insulated coupling is provided for detaching this entire end of the shaft carrying the wheel, from the other end carrying the armature.

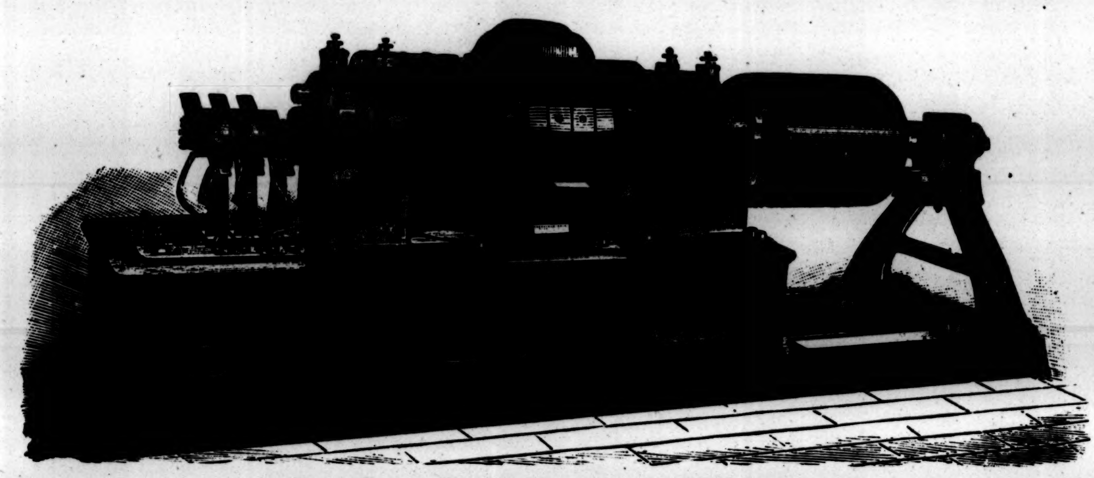
These Brush generators are each of 130 horse-power capacity, and are compound-wound for constant current. The electrical curve from the machines is almost ideally perfect, and they require no regulator whatever. The current remains of constant strength under all conditions of load.

The head of water at the underground chamber is 1,680 feet. It has never before been attempted to run a water-wheel under such enormous pressure. This was, indeed, one of the most serious problems involved in the remarkable installation. From the various excellent forms of water-wheels, the "Pelton" was selected as best adapted to work under the special circumstances. This wheel is the outgrowth of the old hurdy-gurdy form, and, as will be seen from the illustration, its buckets are provided with a very ingenious wedge-shaped partition, by which the stream of water is divided and sweeps out through the curved sides in such a way as to produce a reactionary effect in addition to the impact. By the peculiar construction of the buckets all the water is also thrown down and out of the way of the wheel. The six Pelton wheels are each forty inches in diameter, are made of phosphor-bronze, and weigh 220 lbs. They drive the generators at a speed of 900 revolutions per minute. The compact arrangement of combined dynamo-generator and water-wheel makes it almost impossible for the visitor to the underground chamber to realise the enormous amount of power here at work. The machines are placed in parallel rows of three, and the swift revolving armatures are all that can be seen in motion as evidence of the 800 horse-power generated. The chamber is brilliantly lighted by 36 Swan incandescent lamps operated in multiple series from one of the Brush generators, and there are several of the same lamps in the incline. Each generator circuit is provided with a dead beat ammeter of the Brush pattern, and a Brush voltmeter is also at hand which is capable of measuring up to 3,000 volts. The generator circuits are led to a switchboard in the same dynamo room, where any generator can be thrown on to any one of the outgoing motor circuits.

Leaving this subterranean power station and ascending the Chollar shaft are the circuits of copper wire, one to each generator. At one point these circuit wires pass through a shower-bath of spray, but the insulation is so perfect that no leakage has yet developed. The wires issue from the mine shaft, and are carried above ground to the electric motor room at the Nevada Mill. The total length of each circuit is a little more than a mile.

The electric motor room is shown in one of the large illustrations. The six motors are of the regular Brush constant current type, each of 80 horse-power capacity, and are arranged in a single row parallel with the main driven shaft, to which they are all belted in the ordinary manner. The surface water-wheel is also connected to this same shaft. It will be noted that there is here a very novel and interesting feature. This surface wheel uses the water in the first instance and furnishes part of the power to drive the main shaft. The waste water after this primary use is carried down the Chollar shaft to the underground chamber, where it drives the dynamos which generate the electric current and energise the electric motors above ground, which, in turn, furnish additional power to the main shaft.

Each electric motor has its own independent circuit fed from one of the generators. The well known Brush centrifugal governor with which each motor is fitted, regulates the speed sensitively, and all or any number of the motors work perfectly in a battery together or with the waterweel. In the motor room there is also an ammeter for each electric motor to show at all times the current flowing in each circuit. The motors run at a speed of 850 revolutions per minute. Some difficulty was anticipated in operating the motors together on one shaft in the manner described, but none was encountered. The motors have not given a moment's trouble or annoyance of any kind from the start.



BRUSH DYNAMO-ELECTRIC GENERATOR, 130 HORSE-POWER.

Some idea of the economic value of this electric power plant to the mine owners may be got from a statement of the saving effected by it. The surface wheel alone requires 312 miner's inches of water to develop power sufficient to drive 40 of the 60 stamps with which the mill is equipped. Moreover, this amount of water is seldom available. Two of the electric motors, working in addition to the surface wheel, will perform the same service with but 72 miner's inches of water, thus effecting a saving of about 77 per cent.

The net commercial efficiency of the plant, taking into account all elements of loss, including that in the conducting wires, is about 70 per cent. In other words, 70 per cent. of the power applied to the shafts of the generators in the underground chambers, is delivered for work at the main line shaft in the mill.

The waste water from the 1,650 feet level of the Chollar mine is piped into the Sutro tunnel. It is now proposed to use this water a third time at a lower level for other work by means of a similar application of electrical machinery.

It was expected at the outset that many difficulties would be met in an installation of such novel and original character, which was also by far the largest ever attempted. The projectors, the Brush Electric Company, and their agents, the California Electric Light Company, who assumed charge of the details of the erection, were very greatly pleased to find that their forethought had eliminated the troubles anticipated and predicted in almost all respects. Two purely technical difficulties were encountered when the plant was started experimentally, which caused some delay and anxiety. They were, first, the lack of any governing appliance for the water wheels, and second, the damage to the primary generators caused by the extreme heat and dampness in the underground station.

The Brush Electric Company in its original plans and specifications stipulated that the water wheel should be governed within reasonable limits, but this requirement was not met, and the first generator and motor started up experimentally, showed the necessity of this provision. The Brush Company was surprised to receive by the telegraph the first intimation that the makers of the water-wheels had wholly neglected such an important matter, but was fortunately able to close the breach at once. A water-wheel governor, invented and sketched out by Mr. W. B. Devereux, the prominent mining engineer, of Aspen, Colorado, had been placed in the hands of the company some time previously, and working drawings of it had been made at Cleveland. These were at once sent to California, the governors were quickly made, and this source of trouble was overcome. Mr. F. E. Smith, the electrical engineer in charge of the installation, made several modifications of the governor, after watching its performance, which proved of much value, and it has worked perfectly in practical service. We expect to be able to present our readers with illustrations of this water-wheel governor in a later issue.

The second difficulty was met with equal promptness, and likewise entirely overcome. The temperature of subterranean power chamber is about 72° F. The atmosphere is almost saturated with moisture—78 per cent. Any piece of metal taken into it begins immediately to "sweat." The generators when placed in this chamber were soon covered and saturated with moisture, and began to show leaks, while the motors above ground were absolutely free from any trouble.

The Brush Company was at once notified of this unanticipated source of difficulty, and Mr. Brush speedily devised a method of insulation which would certainly and completely resist the moisture of the saturated atmosphere. Since its application the generators have worked admirably, and the entire plant is now at work regularly, performing its expected duty, and economising the power available, as stated above.

The achievement of the Brush Electric Company in connection with this plant on the Comstock is a very notable one, and of the greatest interest to mining engineers. The plant is by far the largest electrical power plant in the world. The company is making a speciality of powerful generators and motors for power transmission and distribution, and is taking large orders for them, not only in this country, but also for foreign shipments. The latest contract announced is one with the Calumet and Hecla Mining Company, for five of the large Brush generators of 130 H.P., and five of the 80 H.P. Brush motors. A power station will in this case be built above ground for the generators, and the motors will be used for driving pumps under ground. The plant goes to the great copper mine at Calumet, Michigan.

ON THE INFLUENCE OF GAS AND WATER PIPES IN DETERMINING THE DIRECTION OF A DISCHARGE OF LIGHTNING.*

By HENRY WILDE.

ALTHOUGH the invention of the lightning conductor is one of the noblest applications of science to the wants of man, and its utility has been established in all parts of the world by the experience of more than a century, yet a sufficient number of instances are recorded of damage done by lightning to buildings armed with conductors to produce in the minds of some an impression that the protective influence of lightning conductors is of but questionable value.

The destruction by fire of the beautiful church at Crumpsall, near Manchester, during a thunderstorm on the morning of the 4th instant, has induced me to bring before the Society, with a view to their being known as widely as possible, some facts connected with the electric discharge which have guided me for some years in the recommendation of means by which disasters of this kind may be averted.

For the proper consideration of this subject, it is necessary to make a distinction between the mechanical damage which is the direct effect of the lightning stroke, and the damage caused indirectly by the firing of inflammable materials which happen to be in the line of discharge.

Instances of mechanical injury to buildings not provided with conductors are still sufficiently numerous to illustrate the terrific force of the lightning stroke, and at the same time the ignorance and indifference which prevail in some quarters with respect to the means of averting such disasters; for wherever lofty buildings are furnished with conductors from the summit to the base and thence into the earth, damage of the mechanical kind is now happily unknown.

Even in those cases where lightning conductors have not extended continuously through the whole height of a building, or where the lower extremity of the conductor has, from any cause, terminated abruptly at the base of the building, the severity of the stroke has been greatly mitigated, the damage being limited in many cases to the loosening of a few stones or bricks.

The ever-extending introduction of gas and water pipes into the interior of buildings armed with lightning conductors has, however, greatly altered the character of the protection which they formerly afforded; and the conviction has been long forced upon me that, while buildings so armed are effectually protected from injury of the mechanical kind, they are more subject to damage by fire.

The proximity of lightning conductors to gas and water mains, as an element of danger, has not yet, so far as I know, engaged the attention of electricians; and it was first brought under my notice at Oldham in 1861, by witnessing the effects of a lightning discharge from the end of a length of iron wire rope, which had been fixed near to the top of a tall factory chimney, for the purpose of supporting a long length of telegraph wire. The chimney was provided with a copper lightning conductor terminating in the ground in the usual manner. In close proximity to the conductor and parallel with it the wire rope descended, from near the top of the chimney, for a distance of 100 feet, and was finally secured to an iron bolt inserted in the chimney about 10 feet from the ground. During a thunderstorm which occurred soon after the telegraph wire was fixed, the lightning descended the wire rope, and, instead of discharging itself upon the neighbouring lightning conductor, darted through the air for a distance of 16 feet to a gas meter in the cellar of an adjoining cotton warehouse, where it fused the lead pipe connections and ignited the gas. That the discharge had really passed between the end of the wire rope and the lead pipe connections was abundantly evident from the marks made on the chimney by the fusion and volatilisation at the end of the wire rope and by the fusion of the lead pipe. As the accident occurred in the daytime, the fire was soon detected and promptly extinguished.

Another and equally instructive instance of the inductive influence of gas pipes in determining the direction of the lightning discharge occurred in the summer of 1863 at St. Paul's Church, Kersal Moor, during divine service. To the outside of the spire and tower of this church a copper lightning conductor was fixed, the lower extremity of which was extended under the soil for a distance of about 20 feet. The lightning descended this conductor, but, instead of passing into the earth by the path provided for it, struck through the side of the tower to a small gas pipe fixed to the inner wall. The point at which the lightning left the conductor was about 5 feet above the level of the ground, and the thickness of the wall pierced was about 4 feet; but beyond the fracture of one of the outer stones of the wall and the shattering of the plaster near the gas pipe, the building sustained no injury.

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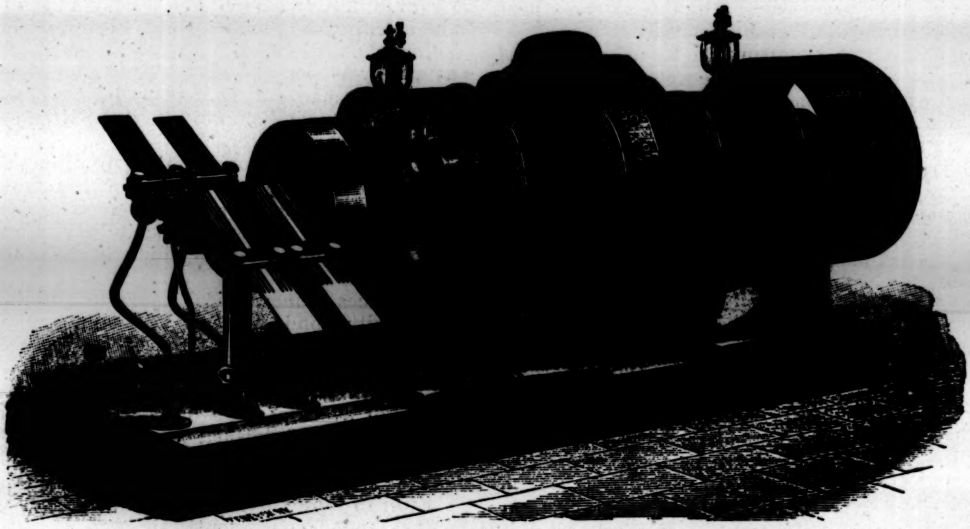
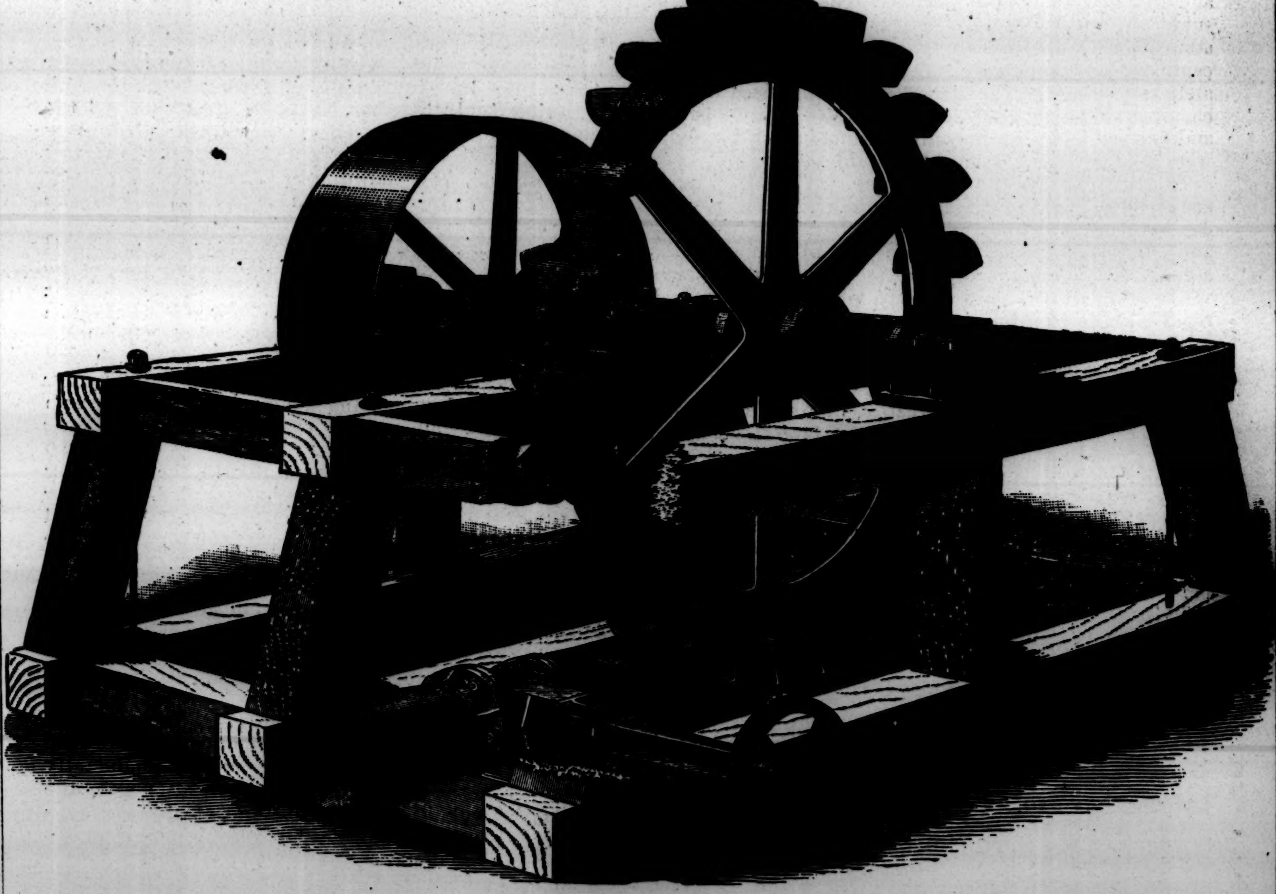
* From the Proceedings of the Literary and Philosophical Society of Manchester, January 9th, 1872.



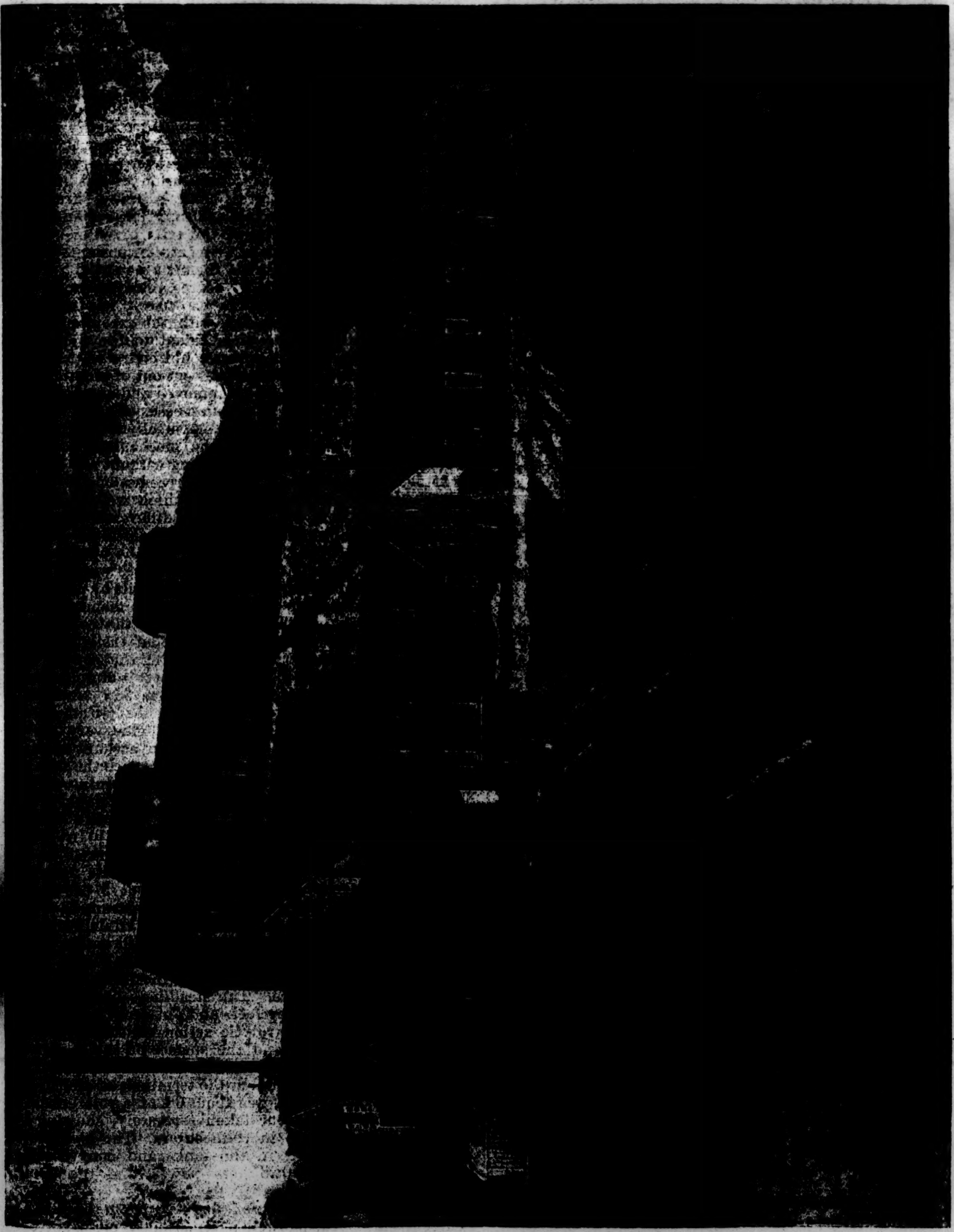
BRUSH AUTOMATIC ELECTRIC MOTOR, 1 TO 100 HORSE-POWER (See p. 678).



THE PELTON WATER-WHEEL (See p. 678).

That the direction of the electric discharge had in this case been determined by the gas pipes which passed under the floor of the church was evident from the fact that the watches of several members of the congregation who were seated in the vicinity of the gas mains were so strongly magnetised as to be rendered unserviceable.

The church at Crumpsall is about a mile distant from that at Kersal Moor, and the ignition of the gas by lightning, which undoubtedly caused its destruction, is not so distinctly traceable as it is in other cases which have come under my observation, because the evidences of the passage of the electric discharge have been obliterated by the fire. From information, however, communicated to me by the clerk in charge of the building, as to the arrangement of the gas pipes, the most probable course of the electric discharge was ultimately found.



THE NEVADA STAMP MILL. (See p. 676)

The church is provided with a copper lightning conductor, which descends outside the spire and tower as far as the level of the roof. The conductor then enters a large iron down spout, and is carried into the same drain as that in which the spout discharges itself. Immediately under the roof of the nave and against the wall a line of iron gas pipe extended parallel with the horizontal lead gutter which conveyed the water from the roof to the iron spout in which the conductor was enclosed. This line of gas piping, though not in use for some time previous to the fire, was in contact with the pipes connected with the meter in the vestry, where the fire originated, and was not more than 3 feet distant from the lead gutter on the roof. As no indications of the electric discharge having taken place through the masonry were found, as in the case of the church at Kersal Moor, it seems highly probable that the lightning left the conductor at the point where the latter entered the iron spout, and by traversing the space between the leaden gutter and the line of gas piping in the roof found a more easy path to the earth by the gas mains than was provided for it in the drain.

In my experiments on the electrical condition of the terrestrial globe* I have already directed attention to the powerful influence which lines of metal, extended in contact with moist ground, exercise in promoting the discharge of electric currents of comparatively low tension into the earth's substance, and also that the amount of the discharge from an electrometer into the earth increases conjointly with the tension of the current and the length of the conductor extended in contact with the earth. It is not, therefore, surprising that atmospheric electricity, of a tension sufficient to strike through a stratum of air several hundred yards thick, should find an easier path to the earth by leaping from a lightning conductor through a few feet of air or stone to a great system of gas and water mains, extending in large towns for miles, than by the short line of metal extended in the ground which forms the usual termination of a lighting conductor.

It deserves to be noticed that in the cases of lightning discharge which I have cited the lightning conductors acted efficiently in protecting the buildings from damage of a mechanical nature, the trifling injury to the church tower at Kersal Moor being directly attributable to the presence of the gas pipe in proximity to the conductor. Nor would there have been any danger from fire by the ignition of the gas if all the pipes used in the interior of the buildings had been made of iron or brass instead of lead; for all the cases of the ignition of gas by lightning which have come under my observation have been brought about by the fusion of lead pipes in the line of discharge. The substitution of brass and iron, wherever lead is used in the construction of gas apparatus, would, however, be attended with great inconvenience and expense, and moreover would not avert other dangers incident to the disruptive discharge from the conductor to the gas and water pipes within a building. I have therefore recommended that in all cases where lightning conductors are attached to buildings fitted up with gas and water pipes the lower extremity of the lightning conductor should be bound in good metallic contact with one or other of such pipes outside the building. By attending to this precaution the disruptive discharge between the lightning conductor and the gas and water pipes is prevented, and the fusible metal pipes in the interior of the building are placed out of the influence of the lightning discharge.

Objections have been raised by some corporations to the establishment of metallic connection between lightning conductors and gas mains on the ground that damage might arise from ignition and explosion. These objections are most irrational, as gas will not ignite and explode unless mixed with atmospheric air, and the passage of lightning along continuous metallic conductors will not ignite gas even when mixed with air. Moreover, in every case of the ignition of gas by lightning, the discharge is actually transmitted along the mains, such objections notwithstanding. A grave responsibility therefore rests upon those who, after introducing a source of danger into a building, raise obstacles to the adoption of measures for averting this danger.

ELMORE COPPER DEPOSITING PROCESS.

A GOOD deal has been heard lately with regard to this process, introduced by Messrs. Woodhouse and Rawson, Limited, and notwithstanding that a large number of reports from eminent men were contained in the prospectus issued with reference to the Elmore Company for working the patents in England, the results of the process were almost believed to be too good to be true.

Lately some trials have just been finished at the works of one of the principal manufacturing companies abroad at their own factory, which places the results of the Elmore process beyond dispute, and more than proves the statements made by the inventors. It is well known that the process consists of depositing copper upon a rotating mandril from a sulphate of copper solution, but the valuable portion of the invention relates to the mechanical working of the surface of the metal from one end of the mandril to the other by means of an agate burnisher having a few pounds pressure. By these simple means a very remarkable change takes place in the constitution of the metal, which is found to possess extraordinary strength coupled with remarkable malleability. These points are fully shown in the results of the tests given later on. The instruments used for arriving at the constants were a Carpentier ammeter and a Siemens potential galvanometer reading ·01 volts per degree, the dynamo being a one horse Gramme machine. Work was carried on continuously for 10 days, with the exception of a short stoppage caused by an accident to the dynamo, but no bad results in the tubes could be traced. After five days' working one tank was cut out of circuit, the mandril with the tube upon it removed and another one put in and started with the greatest ease. The attention necessary during the operations is of the slightest possible kind, the whole of the mechanical portion being purely automatic, and working without any hitch whatever. Naturally, as in most processes of a similar kind, there are numerous points which we are not at liberty to mention, which make the difference between success and failure, but these merely consist in details which are not subject to variation, and the working of the process is simplicity itself. Five tubes were made, these were separated from the iron mandrils by pressure being applied to the copper while the mandril was rotating in a lathe. The expansion of the copper is sufficient to enable the tube to slide off easily, but in regular work the method of expanding the copper by superheated steam will be employed as it is simpler and cheaper. The mean current used was 36·7 ampères, giving a current density of rather more than 15 ampères per square inch of cathode surface. This very high current density is no doubt possible on account of the use of the burnisher, and is more than twice the maximum found advisable in ordinary copper refining without the burnisher. The E.M.F. of each tank was taken separately at the terminals, the average being as nearly as possible 0·9 volt per tank. In connection with this point, it may be remarked that after about 36 hours the E.M.F. reaches its normal point, being at the commencement about 5 per cent. higher, and that the reading of the instrument was perfectly steady in spite of the well-known delicacy of the Siemens instrument. This fact is important in connection with the method of connection with the rotating mandril, which is made by means of a brush pressing on its surface. The steadiness of the voltmeter was practically perfect, and, in fact, there is to all appearance an electrolytic action constantly going on between the brush and the surface of the mandril which tends to keep the contact remarkably perfect. The total E.M.F. measured at the terminals of the four tanks, taken as a whole, was about 0·1 of a volt greater than the sum of the four taken separately, showing a remarkably small loss in connections. The electrical horse-power absorbed in the tanks and connections amounted to about 0·28 horse-power, and the total copper deposit was about 104 lbs.

A very careful calculation deduced from the mean current employed, showed a remarkably close agreement between the theoretical and actual quantity of copper deposited. The thickness of copper deposited was 0·14 inches, being as nearly as possible at the rate of one-eighth of an inch per week.

Exhaustive tests were made upon portions of the tubes made after their removal from the baths: the metal had a breaking strain of 32·3 and 32·7 tons per square inch with an elongation of 7·5 and 10 per cent. on 8 inches of length respectively in a longitudinal and transverse direction. In connection with the question of elongation, it should be remarked that in ordinary practice the ductility of a metal has been gauged by its elongation as given by the test machine. With the burnished copper the ductility is almost perfect with a relatively very small elongation, showing the completely new nature of the metal. This point was fully demonstrated by Mr. W. Parker, of Lloyds, in his paper read before the Society of Arts, where he states that the ductility of burnished copper with a 13 per cent. elongation, is greater than ordinary copper with an elongation more than three times as great. The fracture of one piece in the testing machine was arrested the moment before it was completed in order to show the extraordinary symmetry, the metal beginning to flow exactly at the centre line and showing almost precisely equal percentages of elongation on either side of the line. The annealed test piece which, from the appearance of the metal, led to the conclusion that they had been overheated, gave a breaking strain of 15·4 and 16·8 tons with an elongation of 23 and 31 per cent. on 8 inches. As is known, wire is made by this process by taking a deposited tube and shearing off a continuous square strip, beginning at one end, until all the tube is converted into one continuous length of copper strip, thus doing away with the numerous processes of remelting, casting and sawing up by which all high conductivity wire is made, the deposition of the metal being required in both cases. Portions of the tube were drawn down from a thickness of 3·4 mm. to 1 mm. through 14 hard holes without annealing instead of having to be annealed every few holes. A test of this wire gave a breaking strain of 35 tons per square inch. Another sample of the same diameter was annealed and then drawn through 15 hard holes to a diameter of 0·98 mm. giving a breaking strain of 32·4 tons per square inch. A portion of this wire annealed and drawn through 7 holes to a diameter of 0·53 mm. and then annealed gave a breaking strain of 20·4 tons per square inch with an elongation of 33 per cent. on 4 inches of length; thus showing not only that the wire when finished was of a very high quality —it being recollected that the conductivity, as shown by experts, is over 102 per cent.—but the drawers are enabled to draw the unannealed down through many more holes than they can now draw annealed copper. A portion of a tube was annealed and rolled cold from 3·5 mm. to 1 mm. thickness and gave when finished 26 tons per square inch breaking strain. In both the wire drawing and the rolling the metal showed very exceptional qualities as regards ductility, and the above figures are sufficient evidence of its extraordinary strength. In addition, however, some interesting experiments were made of its behaviour under the hammer. At first, the opinion of the workman employed to make these tests was that nothing could be done with the metal on account of its hardness. In spite, however, of his opinion he was perfectly successful in hammering a broad flange 2½ inches in width, on the edge of which he hammered out a tongue ·012 inches, or less than $\frac{1}{10}$th of the original thickness of the tube, without the slightest sign of a crack in the metal. The extraordinary quality of the metal was plainly observable by the way in which the workman showed his hesitation in going any farther with the test, and his final opinion, openly expressed, was that it appeared so ductile that it was impossible to break it under the hammer.

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* *Philosophical Magazine*, August, 1868.

Several other exceptional tests were put to the metal, all of which it successfully stood, and in the case of an annealed portion of the tube after a further tongue had been hammered on its edge the tongue was turned over and hammered flat without any signs of either breaking or cracking. It is impossible to give any exact idea of the value of these tests to those unacquainted with the nature of copper working, but it may be remarked that the single fact of the possibility of hammering a flange in the tube of this metal without annealing it once, places it in an entirely different category to any other class of tubes in which the annealing which is necessary to enable the tube to be worked, at once robs the metal of a large percentage of its strength, whereas the burnished metal remains unimpared at the very point where strength is principally required.

Again, in the wire drawing process the nature of the metal was plainly shown by the ease with which the wire was reduced at each draft, and by the way in which it passed through the draw plate, even when kinks had been purposely made in the wire in order to notice their effect as the wire passed through.

In one respect the copper showed a very remarkable difference from ordinary copper. There is a growing tendency among engineers to regard the elastic limit of the metal as the real test of its commercial value in the matter of withstanding strains. In this respect the burnished metal shows a very high result, the ratio of elastic limit to breaking strain being as high as 61 per cent., and an English test on a similar tube gave a figure as high as 82 per cent.

There were many indications that the limit of the reduction of H.P. necessary for producing a given weight of copper has not yet been reached, but a very short inspection of the above figures will show what a remarkably small amount of motive power is required to produce a ton of copper in the form of finished tubes possessing qualities far above those yet attainable by any known and much more expensive processes; whether we regard the simplicity, the certainty, or the cheapness of the process, we are equally struck with the remarkable advance upon the ordinary methods now employed.

The tests were carried out in the works of one of the largest copper producers in the world, and therefore ample opportunities occurred for comparing the new type of metal with the ordinary, and it was plain that in every respect the superiority of the new was fully recognised by men thoroughly capable of judging.

Mr. Stepney Rawson was present during the whole of the trials on behalf of Messrs. Woodhouse & Rawson, Limited, and the above figures are taken from his official report, which we have seen.

Mr. Rawsons's reputation as a careful and accurate investigator, combined with his extensive knowledge of electrical science, appear to be a sufficient guarantee of the genuineness of the trials.

LINES OF ELECTRICAL INDUCTION.

MR. R. W. CHAPMAN, of Adelaide University, South Australia, has sent the following interesting communication to the *Scientific American*:—

Some very pretty experiments may be made, and the lines of electrical induction between two electrified bodies may be shown extremely well, by the use of the fine white needle-like crystals of sulphate of quinine suspended in a good insulating liquid, such as pure turpentine. To perform the experiments, take a flat glass dish and pour in turpentine to the depth of about a quarter of an inch, sprinkle this with sulphate of quinine evenly distributed till the turpentine assumes a milky appearance. If now a brass ball connected by a chain with an electrical machine be placed at one end of the vessel, and another connected with earth at the other end of the vessel, on working the machine the crystals of quinine will become polarised and take up their positions end on end, forming very distinct curved lines between the balls in exactly the same way as iron filings form in lines of magnetic induction when sprinkled over a magnet. The symmetrical lines of white crystals when shown up by a dark background look extremely beautiful. We have here the basis for a set of experiments which may be diversified to an almost unlimited extent by varying the number and shapes of the electrified bodies placed in the turpentine.

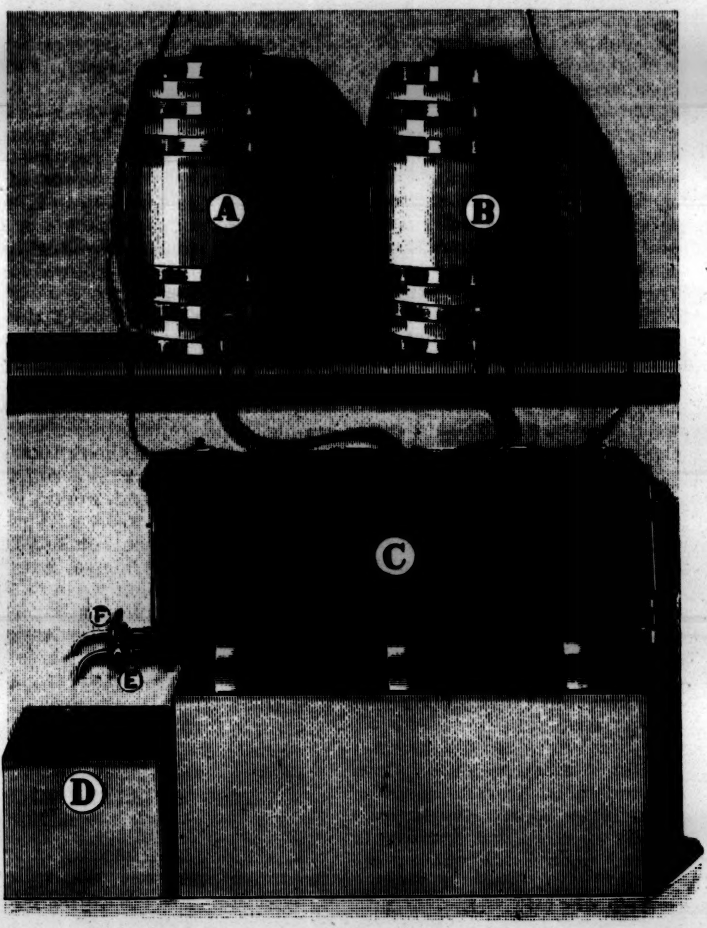
The fact that there is no electrical force within a hollow conductor may be very prettily shown by connecting both of the balls in the above experiment with the machine and placing in between them a large metal ring connected with earth. The curved lines are then very distinctly shown running from each ball to the ring, but within the ring the turpentine remains in the uniformly cloudy state in which it was initially, the crystals showing no disposition to place themselves end on end. The difference in the appearance of the quinine particles outside and inside the ring is very striking. If now a small third ball be connected with the machine and placed in the centre of the metal ring, the appearance of the turpentine within the ring is entirely changed, and the crystals form in straight radial lines from the centre to the circumference.

By multiplying the number of the electrified balls, charging some positively and others negatively, the resulting lines of induction may be made very complicated, but, provided that there is a fair space between the balls, the lines are always distinctly and clearly mapped out by the crystals. It is an easy matter to obtain some very beautiful figures by symmetrical distributions of the electrified bodies.

In making the experiments it is very necessary that the turpentine should be pure and dry, as a very slight amount of impurity is sufficient to destroy its powers as an insulating medium. Benzine will answer, and it possesses the additional advantage of not dissolving any of the quinine, while turpentine dissolves it to a slight extent, but its specific gravity is so small that the crystals fall to the bottom of the vessel almost at once, and adhere to it, so that they will not easily take up the lines unless the experimenter be sufficiently quick to electrify the balls before the particles reach the bottom. On the whole, turpentine I have found to give the most satisfactory results. After the crystals have once been electrified inductively in this way, they appear to take up the lines much more easily a second time. It seems as though the molecules do not recover altogether from the effects of the electric strain.

THE WEYMERSCH BATTERY.

In our issue of June 22nd, 1888, we called attention to M. Weymersch's improved form of Bunsen battery as possessing advantages calculated to bring it into extensive use for certain purposes, and as being the nearest approach ever made to the ideally perfect primary battery. The India Rubber, Gutta Percha and Telegraph Works Company, of Silvertown, is now manufacturing these batteries, and has issued a circular explanatory of the arrangement, method of charging, prices, and other particulars. The battery is recommended as being "well adapted for private installations where it is not convenient to employ motive power actuating a dynamo machine; it is also very suitable for driving motors for sewing machines, lathes, dental machines, train lighting, and for electro-plating. The standard battery, as shown in the illustration, gives about 13 volts on open circuit, and can be worked for seven hours per charge with a current of 13 to 14 ampères, the current remaining during this time practically constant. Two standard batteries joined together will run ten 8-candle-power or 16 5-C.P. incandescent lamps for the above period, during which time there are no fumes from the solutions. Although for running the full number of lamps the solutions are considered exhausted after a seven hours' run, yet, if the number of lamps is reduced, a further run of three to four hours can be obtained.



"The battery of the form shown consists of a rectangular ebonite trough divided into six cells by means of ebonite partitions. In each cell is fixed a rectangular porous pot fitted with an ebonite pipe, by means of which all the porous pots are connected together. In a like manner all the outside cells are connected, and the pipes are fitted with ebonite taps. Levels or gauge glasses are fitted to show the level of the liquids in the porous pots and outside cells. The positive element is zinc, two plates being used for each cell, and the negative element carbon. The zincs are placed in the outside cell with the exciting liquid, and the carbon and depolarising liquid in the porous pot. The zincs are sent out specially amalgamated, and if the current is not allowed to exceed 15 ampères they will not require reamalgamating.

"The general arrangement of this battery has been made with a view to reducing the attention required to a minimum, and this arrangement permits of the entire battery being charged or emptied in five minutes by merely opening the proper taps. The diagram shows the arrangement by means of which all the usual disagreeable labour of charging or exhausting is entirely done away with.

"The stoneware barrels, A and B, are placed on a stand or shelf above the battery level, each barrel being fitted with a stoneware tap, to which is attached a length of India rubber tubing. In the top of the battery are two filling holes—one for the porous pots, and the other for the outside cells. A small stoneware sink, D, is fixed underneath the battery taps, E and F.

"To charge the battery, the depolarising solution is put into the stoneware barrel, A, and the exciting liquid into the stoneware barrel, B. The tubes are now put into the proper holes (marked) through the top of the battery, and the barrel taps opened. The solutions should be allowed to flow until they rise to the marked point on the levels, when the taps should be closed, and the battery is ready for work. After the solutions are exhausted, open the battery taps and allow the spent solutions to flow away. The entire work of emptying and recharging occupies a few minutes. The barrel has a capacity of 6 gallons, sufficient for four charges of the six-cell battery."

LIGHTNING CONDUCTORS.

By S. ALFRED VARLEY.

(*Continued from page* 653.)

IN the earlier portion of this article it was suggested that induction had no real place in "Modern Views of Electricity," and, secondly, that induction was the keystone of the Franklin-Faraday theory.

I freely acknowledge that could it be fairly demonstrated a Leyden jar discharge is oscillatory, then sooner or later all electricians would have to admit that the theory Prof. Lodge is now doing battle for is a step in advance; but, on the other hand, if the analysis of the mechanism of a Leyden jar discharge given in this article be complete, as I contend it is, then I venture to say not many years will elapse before the newer theory will have to be practically abandoned.

In an interesting lecture on thunderstorms, delivered by Prof. Tait, and referred to in the Dr. Mann lectures, the following passage occurs: "One great object which he (Clerk Maxwell) kept before him during the whole of his scientific life was to reduce electric and magnetic phenomena to mere stresses and motions of the ethereal jelly, and there can be little doubt that he has laid the foundation of an electric theory of light, admirably simple in its fundamental assumptions, but, like it, requiring the utmost resources of mathematical analysis. It cannot but seem strange to the majority of you to be told we know probably as much about the secret mechanism of electricity as we do about that of light, and that it is more than exceedingly probable that a ray of light is propagated by electric and electromagnetic disturbances."

Notwithstanding what is stated in the above quotation, it is humbly submitted that electricians know quite as much about the nature of electricity as is known about light, and that the knowledge we possess amounts to, just nothing at all.

Our experience with the behaviour of electricity is certainly more varied than that of light, for electricity, as Prof. Dolbear has happily expressed it, is our obedient servant of all work, and as everything in Nature is so intimately connected, it may well be, that this useful servant of all work is concerned in the propagation of a ray of light. It would, however, I suppose, be heresy to suggest that perhaps Sir Isaac Newton's theory of light may, after all, be proved to be truer than the undulatory one, and that possibly it is the theory of light, rather than that of electricity, which really needs correction. Be that as it may, it ought not to be overlooked that scientific advances are to be sought for in the direction of further simplicity, rather than in complexity, and this newer theory is acknowledged to be singularly complex.

The chief credentials of the oscillatory theory are in a great measure the acknowledged mental greatness of its propounder; it has been deduced from theoretical reasoning, and is not the outcome of experiments. That being so, excepting so far as Prof. Lodge's experiments may be considered to have demonstrated its truth, it must be regarded as an unproved hypothesis.

Hypotheses may have their bases in truth, but it may be safely affirmed there never has yet been a really true hypothesis.

The Franklin-Faraday theory can be scarcely called a hypothesis; it is the outcome of experiments, all of them pointing in a uniform direction, which have suggested the theory, and not the theory which has given rise to the experiments. The Franklin-Faraday theory therefore rests on a very firm and broad basis.

I proceed to make a few remarks on Leyden arrangements. At one end of the scale we have the ordinary Leyden jar, the conducting coatings of which are separated by glass, a dielectric possessing great cohesive strength, and whose inductive resistance is considerable; at the other end of the scale we have a pair of polarised plates separated by an electrolytic liquid of low resistance. The cohesive strength of glass being great, in an ordinary Leyden jar a statical charge of high potential can be accumulated; but as the inductive resistance of glass is considerable, the quantity of electricity which can be stored up is small.

The conditions prevailing in the case of polarised plates divided by an electrolytic liquid are the very reverse of those of an ordinary Leyden jar; the quantity which can be stored up in such Leyden arrangements is very great, and the potential of the charge is correspondingly low, and for the reasons that the low resistance to induction which an electrolytic liquid opposes, permits induction to take place through it very freely; at the same time the feeble cohesive force of the liquid dielectric opposes but little resistance to the reunion of the accumulated + and − electricities through it by discharge.

In considering Leyden arrangements and their bearing on lightning phenomena, the relationship of the cohesive force binding together the molecules of the dielectric to the inductive resistance (or, as it is more commonly termed, the inductive capacity) of the dielectric must not be overlooked.

Faraday has shown that the specific inductive capacity of sulphur, shellac, glass, and some other dielectrics is much greater than that of air; for example, according to Faraday the specific inductive capacity of sulphur compared with air is as 2·24 to 1, shellac as 2 to 1, and glass as 1·76 to 1; at the same time, the cohesive force binding the molecules together of the three above-mentioned dielectrics is much greater than air, and consequently Leyden jars constructed with any of these above-mentioned dielectrics are capable of accumulating statical charges of larger quantity and higher potential than is possible with a Leyden arrangement having a layer of air for its dielectric.

In an ordinary Leyden jar the glass on either side is coated with metal foil, which distributes the electric stress uniformly over the dielectric by bringing the whole of the surfaces of the glass metallically embraced, under the influence of induction.

In the earlier stages of charging the jar, as the opposite electricities are separated by a thin layer of glass only and by a considerable mass of air, nearly the whole of the induction occurs through the glass, but the resistance opposed to the accumulation of a statical charge increases as the square of the potential of the charge, and therefore as charging proceeds, the induction which also occurs through the air increases inversely as the square of the charge accumulated on the surfaces of the Leyden jar, and eventually the induction through the air becomes increased sufficiently to break down a mass of air many times greater in thickness than the glass dielectric of the Leyden jar. We have here an example of a dielectric opposing nearly twice the specific inductive resistance of glass, giving way and acting the part of a conductor, owing to its lower cohesive force.

At the moment preceeding discharge, the energy being expended in charging is balanced by the cohesion of the molecules of the thin layer of glass and the molecules of a much larger space of air, and when discharge does occur through the air, less resistance is opposed by the air than is opposed to further accumulation of charge.

At the time discharge takes place there is powerful attraction between the + and – accumulated charges through the thin layer of glass separting them, and the effect of this would be to prolong the duration of the act of discharge, were it not that the charged surfaces are embraced by metal sheets opposing no appreciable resistance. As is well known, the discharge is exceedingly rapid, and a large Leyden jar may be considered to discharge as quickly through a space of air as a smaller one charged to the same potential does, the only difference being that a larger sectional area of air molecules are broken down by the larger Leyden arrangement, and the discharge consequently is louder and heavier.*

A submarine circuit is an example of a Leyden arrangement, presenting features deserving of notice. Apart from its enormous capacity, which enables phenomena to be readily seen which otherwise could be only guessed at, it is a Leyden arrangement possessing certain characteristic features which distinguish it from other Leyden arrangements.

Faraday considered there was no hard and fast line to be drawn between insulators and conductors, that all conductors insulated more or less, and all insulators conducted. A submarine cable affords evidence of the truth of Faraday's generalisation, the conducting core in the interior of its gutta-percha envelope forms the inner coating of the Leyden arrangement, and the sea the outer coating. Statical charge involves, as is well known, insulation; in fact it may be regarded as the very essence of it, for where there is no insulation statical charge is not possible, but in a working cable the only insulation is the resistance of the copper conducting core, which is electrically connected at both ends of the cable through the instruments to the earth connections, so we have here an example of a Leyden arrangement, the inner and outer coatings of which are united by a good conductor, and as we increase the diameter of the conducting core we decrease the statical capacity of the Leyden arrangement, because the surface of the conductor increases only as its diameter increases, whereas the sectional area or weight of the conductor increases as the square of the diameter. These special distinguishing features of submarine circuits, considered as Leyden arrangements, were quite overlooked by all our mathematical physicists at the time the problem of bridging the Atlantic Ocean was under consideration and the first cable was in course of construction, and it fell to the writer of this article to direct attention to the erroneous electrical views promulgated by the scientific advisers of the original Atlantic Telegraph Company. It also fell to him to point out the distinguishing features of submarine circuits considered as Leyden arrangements, and to indicate their general bearing on the rate of transmission of signals through them.

I refer to the above as an illustration which the history of the practical applications of science affords more than one example of, showing how powerless our greatest scientists (whose training has been preeminently mathematical) are to forsee consequences where applications of science under *new* conditions are involved.*

(*To be continued.*)

REVIEW.

The Working and Management of an English Railway. By **GEORGE FINDLAY**, general manager of the London and North Western Railway. London: Whittaker and Co., White Hart Street, Paternoster Square.

To those who take an interest in the history of the commencement and growth of our railway system, Mr. Findlay's book will be found most entertaining. The writer being naturally deeply interested in the company, of which he is the general manager, no doubt sees everything relating to the same through rose-coloured spectacles, but it can fairly be said that the whole London and North Western Railway system is a credit to the company and to the nation. The general contents of the book are as follows:—"Introductory and Retrospective;" "Management;" "The Staff;" "The Permanent Way;" "Signals and Interlocking;" "Telegraphs;" "Rolling Stock;" "The Working of Trains;" "The Shunting and Marshalling of Goods Trains;" "The Working of Goods Stations;" "Rates and Fares—Division of Traffic—The Railway Clearing House;" "On the relation of the State to railways in England and the Question of State Purchase of Railways;" "On the Law as between English Railway Companies and the Public;" The Railways as an Arm of Defence."

COMPOUND WINDING PATENTS.

KING, BROWN & CO., *v.* ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION, LIMITED.

(*Concluded from page* 668.)

MR. JAMESON maintained that there was no disclosure or purpose in Varley's specification. He appreciated the point about greater or lesser resistance, which showed there was in Varley's mind some notion of the kind; but that suggestion, although it seemed very important to people now, would not necessarily to a workman at the date of the specification suggest that the purpose of having greater or less resistance was that of self-regulation.

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* It may be argued that as with a Leyden jar of large capacity there is more magnetism developed than by a smaller one, there is also more magnetic inertia to be overcome and consequently the act of such discharge embraces a longer period. Undoubtedly this is so.

* My views were brought publicly forward in papers read and discussed before the Institution of Civil Engineers in 1858, and the Society of Arts in 1859. My paper of 1858 can scarcely be said to have been discussed as the scientific advisers of the original Atlantic Telegraph Company, and physicists who had taken an active part in the electrical discussions of that period held their tongues, and had no comments to make when the opportunity for discussion was afforded. The history of submarine telegraphy has cropped up from time to time in presidential addresses and discussions at the Institute of Electrical Engineers. It did so at the last address, but my electrical work, which had a very important bearing at the period referred to, has been consistently ignored and suppressed by our mathematical physicists. How far this is reconcileable with the principles of common honesty may be left to the readers of this Journal. See paper "On the electrical qualifications requisite on long submarine telegraph cables," published in the minutes of proceedings of the Institution of Civil Engineers of 1858; and see paper "On the practical bearing of the theory of electricity in submarine telegraphy, the electrical difficulties in long circuits, and the conditions requisite in a cable to insure rapid and certain communication," published in the proceedings of the Society of Arts of 1859.

Lord Trayner: Would it not suggest something of that kind to the workman, if he found two wires of greater and less resistance?

Mr. Jameson: He would find so many absurd things in the specification that he would think it was another conundrum.

Lord Trayner: And, like the American, he would give it up. (Laughter.) But there was Siebe and Gorman's machine.

Mr. Jameson: They were partners with Varley.

Lord Trayner: That machine showed he knew what he wanted.

Mr. Jameson: Yes, he had a notion in his head about it.

Lord Trayner: If the lamp was used on Varley's machine it must have been in the series shunt. The only time it was used was in connection with the lamp, and therefore the only time it was used was as series shunt.

Mr. Jameson: I doubt if it was.

Lord Trayner: When it was used it was used with that lamp. When it was used with that lamp your own evidence shows that it must have been used as series shunt.

Mr. Jameson: It might have been used in the series without shunt coupling it. There is one thing certain, that the use was so unsatisfactory that they dropped it.

Lord Trayner: Of course, Mr. Jameson, although my observations appear to be adverse to you, they are simply made for the purpose of obtaining information. I have no opinion in the case the one way or the other.

Mr. Jameson proceeded to say that what was proved about this machine was that when the lamp was out it attracted keys and other things. That would be accounted for by the residual magnetism. There was nothing to show that at the time the lamp was there it was not coupled up so as to produce the magnetism of the magnets by a separate excitation arrangement. He did not think it was proved that it was coupled up as a series-shunt at that time, although there were indications that might apply to a series-shunt machine. He submitted that, taking all these things together, a workman would, in the first place, have very great difficulty in constructing a machine at all, and in the next place, the tendency of the whole specification would be to lead his mind to think that some such device as separate excitation was intended, more especially with the arrangement of bobbins. It was impossible to argue that there was anything inconsistent with separate excitation, and there was nothing in the machine as described and shown that pointed to compound winding. Throughout the whole specification Varley was trying to show how his great idea of these bobbins split up into groups could be applied. The same arrangement would take place with regard to the storing up of electricity, which he claimed as his invention. He had no concern or interest to make a special description of any other machine, and having no interest to do so, he did not do so, at all events, so as to be intelligible. He did not describe it in such a way as to enable a workman to make it, according to the opinion of these eminent electricians who had been called as witnesses in the case. As pointed out by Sir William Thomson, Dr. Silvanus Thompson and Prof. Perry, his specification was full of inconsistencies and absurdities. It was founded on an erroneous idea, and was in practice a complete failure, the lamp never having been put in use. It was said, however, that Varley himself made this machine at Siebe and Gorman's. He had made a machine which was series compound winding, but it was a machine that was not necessarily proved to be put to the purpose of being used as a series shunt machine working as a self-regulating machine, or by bifurcation. But even supposing Varley did make it as a series shunt machine, and intended coupling it up, that, of course, would be no disclosure, so far the specification was concerned, unless in the specification he put the public and the ordinary electrical world in as good a position as he was, so far as information was concerned. As to the models which the four witnesses for the pursuer said they made from Varley's specifications, he contended that they would be required to know how much these witnesses had heard about electricity. Immense progress had been made since 1876 in electricity, and it was impossible to judge between these witnesses and the workmen of 13 years ago.

Lord Trayner: If you take the evidence as true, the two lads who were witnesses had no information of any special kind, and yet from the specification they made these models, which were said by your witnesses to represent series shunt winding.

Mr. Jameson went on to contend that Varley's machine was proved to be merely an experimental machine, and he referred his lordship to several cases to show that if a machine was made and used merely experimentally, and then thrown aside and not used, that that would not be held to be anticipation of another machine which was brought forward.

The Court then adjourned.

Upon resuming on Friday, Mr. Jameson, after quoting authorities to show what it was necessary to state in the specification in order to secure a valid patent, proceeded to maintain that it could not for a moment be held that, for purposes of practical utility, Varley's patent had anticipated that of Brush. There was nothing in Varley's specification, even assuming that he actually discovered series shunt winding, to show a workman had to apply it to the purposes of an ordinary electrical machine, and it could therefore lead to no practical or useful result.

Lord Trayner pointed out that there was also this difference in the defenders' favour: that, whatever Varley's purpose was in mentioning double winding, he made no claim for it.

Mr. Jameson considered that was a very important point. As to the question of the experimental use of Varley's machine, after which it was thrown aside, Mr. Jameson held that such experimental use did not in law constitute prior usage so as to invalidate a subsequent patent. Varley's machine was exhibited to a number of friends, and if it had been a machine that was workable it would have been taken up just as Brush's was.

Lord Trayner remarked that there was a break up in the partnership, and there were other reasons given for the machine not being taken up. In other cases much the same thing had been done. Sir Henry Bessemer's invention, which was one of the greatest of the century, was put aside as useless, after he had reduced himself to absolute poverty and made himself practically a beggar in perfecting his system. No foundry would take it up, and it was just as a matter of the purest charity that a man in Birmingham gave him a chance, which resulted in Sir Henry becoming a knight and a millionaire. But his invention lay for years untouched, and nobody would look at it. He spoke with perfect confidence on these points, because he had the facts from Sir Henry himself.

Mr. Jameson pointed out that not even Varley's own skilled witnesses would stand up for the machine.

Lord Trayner did not attach much value to that, because a man might have made endless blunders in his theories about magnetism and electricity and yet make an extremely good practical machine. They were dealing with a defective machine in comparison with a machine which came out subsequently and was not defective. But the question was whether Varley described in his specification and had in view such a machine as would, if money had been expended on it, and it had been put into the market, had done just what Brush's machine was doing now.

Mr. Jameson could say nothing further on that point than this, that after fair and sufficient trial, after being exhibited to people interested in the matter and a deal of money having been expended on it, the machine was not taken up as being a success. There was a difference between this case and that of Sir Henry Bessemer, because the latter's invention meant the fitting up of a special foundry at a great cost.

Lord Trayner said it was more costly, but not enormously so. The smelting process was already there, and it merely meant the fitting up of some additional chambers. An important distinction between the two cases had, however, just passed through his mind. Although Sir Henry Bessemer could find no one to take up his invention and work it, there was no other invention of the kind before his was invented, while in this case another invention was brought out, and it was marketably valuable.

Mr. Jameson argued that the fact of Varley's machine having been thrown aside until it was disinterred for the Crompton case was a very strong presumption that it was a merely experimental machine. If the machine, as a whole, was held to have been used experimentally of course the commutator would go with it. He maintained that the Brush commutator was an important mechanical improvement, and that it was sufficiently disclosed in the provisional specification. Varley's patent did not disclose compound winding necessarily at all, but whether that was so or not it did not disclose it in such a way as to constitute an anticipation of Brush's patent, which described compound winding much more lucidly and with much greater detail for the instruction of workmen. With regard to the use of Varley's machine he held that it was just experimental, and the best test of that was that it had never been heard of since. It was quite against the policy of the patent law, and of the authorities which he had quoted to his lordship to hold that such a machine could constitute a public user so as to invalidate a subsequent patent.

Lord Trayner, at the conclusion of the defence, said he was extremely obliged to Mr. Jameson for his very able argument, which had made a great impression on his mind. His lordship intimated that he would consider the case, and give judgment on some future day.

ELECTRIC MOTOR REGULATION.[*]

By FRANCIS B. CROCKER.

Although this subject is one of great scientific and practical interest, it has not been very frequently or very fully treated up to the present time. Of course, motor regulation is very similar to dynamo regulation, but it is by no means identical with it, and it deserves and requires separate treatment. I do not think it is much exaggeration to say that at the present time there is no subject more generally important to electrical engineers than motor regulation. Considering this fact, it is certainly remarkable that the literature of the subject is so limited. We find stray articles in electrical periodicals, rarely more than a description of one particular invention, and in electrical books, regulation is referred to incidentally in connection with descriptions of the various motors. There is also, to be sure, usually one short chapter devoted to this subject, but it is apt to be either very general, merely mentioning a few regulating devices, or else it is confined to the mathematical analysis of some one particular method.

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[*] A paper read before the American Institute of Electrical Engineers, New York, May 22nd, 1889.

Motor regulation is a subject which is somewhat confusing, and requires, therefore, accurate definition, of the quantities and conditions which enter into it. One case is, at first sight, very similar to another, and yet, more careful consideration will show, very likely, that it is exactly opposite. Take for example the two commonest and most important cases, viz., the constant potential and the constant current motors. The conditions of the two cases are precisely opposite, and the solution of the problem is, naturally, entirely different. To maintain a motor at a constant speed with a variable load, on a constant potential circuit, which is the case of the ordinary shunt motor on the regular 110 volt incandescent circuit, is a very easy problem—in fact, it solves itself. A simple shunt wound motor will run at a practically constant speed on a constant potential circuit, even if the load varies from zero up to the full capacity of the motor. Now, this form of motor is exactly what we would use, even if we did not care to have it regulate. It is customary, to be sure, where very close regulation is required, to wind constant potential motors differentially, *i.e.*, with series as well as shunt coils, but this is not essential for ordinary work.

The case of the constant current motor, on the other hand, is as difficult as the first is easy. It seems as if it had to bear the burden of both. Neither a shunt wound nor a series wound nor a compound wound motor can be used practically on a constant current circuit to maintain a constant speed with variable load. The ordinary series wound motor, which is the natural and common form for the constant current motor, will race away when the load is taken off and increase in speed until it tears apart or strains the armature and ruins the machine. We require some special and very effective device to accomplish the regulation in this constant current case, and it seems to happen that almost every device that has been thought of has serious difficulties and complications. The ordinary, and what would seem to be the best, solution of this problem is to vary the magnetic effect of the field upon the armature directly in proportion to variations in the load. This is effected by cutting out the field coils, and by other methods which will be described later. But there are difficulties with almost all these plans.

These two cases, which, as already stated, are the commonest and most important which occur, and yet which are so very different in almost every respect, give a general idea of what we have to deal with in motor regulation.

In order to fix and hold the rather numerous quantities and conditions that present themselves in connection with motor regulation, a tabular statement of them is given below:—

TABLE I.

Electric Motor Regulation.

1. Hand regulation.
    Usually employed for varying the speed.
2. Automatic regulation.
    Usually employed to maintain constant speed, and is effected by
        Centrifugal governors.
        Dynamometric governors.
        Electro-magnetic devices.

Principal Methods of Motor Regulation.

1. Shunt winding. Fig. 1.
2. Differential winding. Fig. 2.
    Varying external resistance in series with
3. Armature.
4. Field. Fig. 1.
5. Both armature and field.
    Varying internal resistance of
6. Armature.
7. Field by cutting out coils in series. Fig. 3.
8. Field by cutting out coils in multiple arc. Fig. 4.
9. Field by grouping coils in series or multiple arc.
10. Both armature and field. Fig. 5.
    Varying shunt in multiple arc with
11. Armature.
12. Field.
13. Both armature and field. Fig. 6.
14. Varying current in separately excited field.
15. Shunting field magnetism. Fig. 7.
16. Short circuiting field magnetism. Fig. 8.
    Varying commutation by
17. Shifting brushes. Fig. 9.
18. Shifting commutator.
19. Shifting magnetic resultant.
20. Moving pole-pieces away from armature. Fig. 10.
21. Moving armature away from pole-pieces. Fig. 11.

FIG. 1.—SHUNT MOTOR WITH VARIABLE RESISTANCE IN FIELD CIRCUIT.

FIG. 2.—DIFFERENTIAL MOTOR. SELF-REGULATING.

FIG. 3.—SERIES MOTOR WITH SWITCH FOR CUTTING OUT COILS IN SERIES.

FIG. 4.—SHUNT MOTOR WITH SWITCH FOR CUTTING OUT FIELD COILS IN MULTIPLE ARC.

FIG. 5.—MOTOR WITH SWITCH FOR THROWING ARMATURE AND FIELD IN SERIES OR IN MULTIPLE ARC.

FIG. 6.—SERIES MOTOR ON VARIABLE SHUNT.

TABLE II.

List of Possible Cases with Direct Currents.

P = Difference of potential in volts at terminals of motor.
C = Current in ampères supplied to motor.
S = Speed of armature in revolutions per minute.
L = Load or torque in lbs. at one foot radius.

Any of these four quantities may be either constant or variable, making the following combinations :—

Case.	Constant.	Variable.	Example.
1.	P	C S L	Series wound motor with variable load on const. pot. cir.
2.	P S	C L	Shunt or comp. wound motor with variable load on con. pot. cir.
3.	P L	C S	Shunt motor with con. load and var. field resist. on con. pot. cir.
4.	P S L	C	Not practical.
5.	P C	S L	Not likely to occur.
6.	P C S	L	Impossible.
7.	P C L	S	Impossible.
8.	P C S L		Shunt motor with constant load on constant potential circuit.
9.	C	P S L	Shunt motor with var. load on constant current circuit.
10.	C S	P L	Series motor with speed gov. and var. load on const. cur. circuit.
11.	C L	P S	Series on arc const. torque.
12.	C S L	P	Not practical.
13.	S	P C L	Motor with speed gov. and var. load on cir. of var. pot. and cur.
14.	S L	P C	Motor with const. load and speed gov. on cir. of var. pot. and cur.
15.	L	P C S	Motor with con. load without speed gov. on cir. of var. pot. and cur.
16.		P C S L	Motor with var. load without speed gov. on cir. of var. pot. and cur.

FIG. 7.—SERIES MOTOR WITH VARIABLE MAGNETIC SHUNT.

In Table I. motor regulation is divided into hand regulation, which, it happens, is almost always used for varying the speed of a motor by a hand switch, fig. 1, for example, and automatic regulation, which is almost always used to maintain a constant speed, and which is usually accomplished in one of the three following ways :—First, by a centrifugal governor similar to that of the steam engine, operating a switch or other device, fig. 3; secondly, by a dynamometric governor—*i.e.*, a mechanism through which the load or torque of the motor is transmitted, which may also operate a switch and vary the power of the field by the direct effect of changes in the load; thirdly, by an electro-magnetic device, such as a solenoid, through which the current, or a portion of it, is passed, which causes the core of the solenoid to move and operate a switch in accordance with variations in the current, fig. 9.

The table next gives the principal methods used to regulate motors. These consist of different arrangements and combinations of parts to produce different effects or changes in the working of the motor, and they constitute the means which we have to employ to accomplish a certain object in motor regulation. Method 1 is simple shunt winding, which consists in exciting the field magnet with a circuit of comparatively high resistance in multiple arc with the armature (fig. 1). This maintains a motor at constant speed with varying load on a constant potential circuit, and does this all by itself, as it were, without any trouble, as already pointed out. The reason for this is that the field, being fed with a constant potential, is therefore of constant strength, and a slight variation in speed of the armature, about 5 per cent., will vary the current in it from zero up to its full capacity, and therefore vary its power to an equal extent.

Method 2 is differential winding (fig. 2), which is a refinement of the first, by which an almost absolutely constant speed—*i.e.*, within 1 or 2 per cent., may be practically maintained. This consists in winding a series coil of comparatively few turns upon the field magnets, in addition to the shunt winding in the previous case, the series coil being wound in the opposite direction and opposed magnetically to the shunt coil. The effect of this is to slightly weaken the field magnetism as the load on the armature, and consequently its current, increases. This tends to increase the speed of the armature and counteract its tendency to slow down with increased load, thereby almost entirely eliminating even the small variation of 5 per cent. in speed which occurs in the ordinary shunt motor. The paradoxical fact that a shunt motor increases its speed with the weakening of the field magnet is well known, being due to the lowering of the counter electromotive force, and consequent increase of current in the armature as the field magnetism is reduced in intensity.

FIG. 11.—SERIES OR SHUNT MOTOR WITH REGULATOR FOR MOVING ARMATURE OUT OF FIELD.

In the next three methods the external resistance in series with the armature or field, or both, is varied. Method 3 would be very wasteful, and is hardly allowable in good practice, because it is simply destroying the main current to put resistance in the armature circuit. Method 4, varying the resistance in the field circuit is very much less objectionable, and is very convenient and common (fig. 3). This mode can be adopted with a very small loss of

FIG. 8.—SERIES MOTOR WITH VARIABLE MAGNETIC SHORT CIRCUIT.

FIG. 9.—SERIES MOTOR WITH AUTOMATIC DEVICE FOR SHIFTING BRUSHES.

FIG. 10.—SERIES MOTOR WITH DEVICE FOR MOVING POLE PIECES APART.

current, because the field current is only a small part of the total current used in the motor, and the loss of a portion of this small fraction is practically insignificant. Method 5, putting external resistance in series with both the armature and field is open to same objection as Case 3, since it throttles and destroys part of the main current.

The next five modes of regulation, 6, 7, 8, 9 and 10, are theoretically more economical than the preceding, because we vary the internal or useful resistance instead of adding external or dead resistance. Method 6, in which the internal resistance of the armature is varied, is very difficult to carry out in practice, simply because it is hard to get at and change the connections of the armature while it is revolving. One of the few ways devised to accomplish this is to wind the armature with two or more circuits connected to a corresponding number of commutators, whereby one or more of these circuits may be used, thus varying the internal resistance and torque. This is clumsy, and practically little better than using two or more separate motors.

Method 7, cutting out the field coils in series is a very simple and common plan. It is the ordinary way of regulating constant current or other series wound motors. This method, or some modification of it, is one according to which the constant current or "arc" motors of the Baxter, "C. & C.," and Excelsior Companies are constructed. Method 8, of cutting out field coils in multiple arc, is shown in fig. 4, and is especially applicable to shunt wound motors. The different layers, for example, may be respectively connected to the contact points of a switch and thrown into circuit successively, the innermost layer first, &c., thus obtaining the most economical result.

Method 9 of grouping the field coils in series or multiple arc produces very great variations in field resistance, and is a combination of the two preceding cases. Like them, it consists in winding the field with separate circuits which are connected to a switch. This is employed in street car motors to obtain the great variations in resistance and power required of them.

Method 10 is also merely a combination of two or more of the four preceding cases. A simple way of carrying it out is illustrated in fig. 5, and consists in connecting the armature and field either in series or in multiple arc, by which a great variation in the total internal resistance of the machine is obtained.

The next method, No. 11, is open to the same objection as No. 6, because when the armature is shunted the main current of the machine is affected. This is, however, less objectionable than dead resistance, because in most cases it is better to divert the current than to destroy it.

Method 12, like methods 4 and 7, is a useful and common one, because in shunting the field we are merely handling a very small fraction of the total current.

Method 13, varying a shunt in multiple arc with both armature and field, is wasteful, like No. 11. It was, however, the plan by which the first arc motors were regulated, a variable shunt being placed in the main circuit and the motor connected to the terminals of the shunt.

The variations in the shunt, of course, throw more or less current through the motor, thereby varying its power as required.

Method 14, varying the current in a separately excited field, is merely historical, as this class of motors has gone out of use. The plan, however, is a very effective one, because, of course, it is very easy to control the field current when it is produced by a separate source.

Method 15 is shown in fig. 7, and consists in shunting the field magnetism—*i.e.*, diverting the lines of force from the armature through some other path. In the arrangement shown in fig. 7, there is a simple series wound motor with consequent pole field magnet, and if the coils exciting one magnetic circuit are short-circuited, it is evident that the magnetism produced in the other magnetic circuit will be short-circuited or shunted by the former. The short-circuiting of the coils is effected by the variable shunt, as indicated.

Method 16 is very similar to the preceding, and consists in short-circuiting the field magnetism and diverting it from the armature by a keeper, which may be moved towards or away from the pole pieces by means of a screw or other contrivance.

We now come to methods 17, 18 and 19, in which the line of commutation is varied. The first is the well known plan of shifting the brushes. This is very effective and easily carried out, and has, therefore, been used quite extensively, but it has the very serious and almost prohibitory objection that when the brushes are moved from the neutral point they spark very badly. This may be remedied to a slight extent by some heroic plan like blowing out the spark produced. But, as sparking is one of the worst drawbacks of a motor, it hardly seems as if this method of regulation would be permanent.

Methods of regulation which are all right for dynamos may not be allowable in the case of motors, because the former is usually in the hands of skilled men devoted to their care, while motors are often run by ignorant and careless persons.

Method 18, shifting the commutator, is simply another way of doing the same thing as shifting the brushes.

Method 19, shifting the magnetic resultant or direction of lines of force in the armature, may be accomplished by two sets of pole pieces; the relative magnetic strength of which is varied. This is also open to the same objection as shifting the brushes.

Method 20, shown in fig. 10, consisting in moving or separating the pole pieces from the armature, has been used in the Diehl and other motors, but it is rather difficult to carry out mechanically, and introduces a hinge or joint in the magnetic circuit, which is, of course, very undesirable.

Method 21, moving the armature away from the pole pieces, is very much easier to accomplish mechanically, and has a great many advantages as a means of regulation. Mr. S. S. Wheeler and myself have been working for some time on motors in which this method of regulation is employed, and the results we have obtained have been very satisfactory; in fact, we have found it to be extremely simple, effective and reliable.

The second table gives a list of the possible cases of motor regulation which may occur with direct or continuous currents. There are four supremely important quantities or conditions in connection with electric motor regulation, viz., potential, current, speed and load, and it is with reference to one or more of these that practically all motors are designed, built, sold and used. Motors are always distinguished, both in science and in trade, as constant potential or constant current motors; constant or variable speed motors, and constant variable load motors; hence a classification of motors based upon the constancy or variability of these four factors is very convenient, and at the same time scientifically correct. The second table is made upon this plan, and in it the four quantities are represented by their initial letters P, C, S and L, expressed respectively in volts, ampères, revolutions per minute, and torque in pounds at one foot radius, these being the units ordinarily used in practical as well as scientific work. We find that there are in all sixteen different cases, in the first four of which the potential is constant; in the second four the potential and current are both constant; in the third four the current only is constant, and in the fourth four neither the current nor the potential is constant.

Case 1, in which the potential alone is constant, is the case of a series wound motor, for example, with variable load on a constant potential circuit. Such a motor would rise in speed when the load was reduced, and *vice versa*. It would not be at all self-regulating—in fact, it would tend to run at a very high speed with light load, and a very low speed with a heavy load. It is possible to give various other examples, but one is sufficient in most cases. In this case, however, I may say that the ordinary street car motor, fed from a constant potential circuit, is also an example of Case 1, the current being controlled by varying the external or internal resistance, according to one of the methods given in the first table.

Case 2 is that of the ordinary shunt or differential motor, with a variable load on a constant potential circuit. This is self-regulating and maintains its constant speed, as already stated, and is the commonest case of motor regulation met with. The current varies directly with the load.

Case 3 is that of the ordinary shunt motor with constant load, having a variable resistance in the field magnet. This case is shown in fig. 1. Increasing resistance of field circuit would weaken the field magnetism and the motor would run faster and take more current; *i.e.*, current would vary directly with speed.

Case 4 is not a practical one, because, if potential, speed and load are constant, the current cannot be varied without wasting it; that is, any excess of current would be simply destroyed, which, of course, is not permissible.

Case 5 is not likely to occur, because potential and current would not be constant with a variable load and speed, but if it did occur it would require that the speed and load should vary inversely.

Cases 6 and 7 are not practical for the same reason as given in Case 4, because if potential, current and speed were constant the load could not be reduced without wasting electrical energy, and in Case 7 the speed could not be varied without wasting energy.

Case 8 is that in which all four factors are constant, and is best illustrated by a shunt motor with constant load on a constant potential circuit, in which case the current and speed would also be constant.

Case 9 may be illustrated by a shunt motor with variable load on a constant current circuit. The speed would run up as the load reduced. A more common example is a series motor on constant current circuit, with switch for cutting out field coils, or, in short, a constant current motor with variable speed and load.

Case 10 is that of the regular constant current or "arc" motor with governor, such, for example, as the Baxter or "C. & C.;" it is a series motor with a centrifugal governor which operates a switch to cut in and out the field coils as shown in fig. 3. This is, next to the shunt and differential wound motors, the most common and important case of motor regulation.

Case 11 is that of a constant current motor with constant load, with switch for varying field strength. The potential would rise directly with speed, but this case is not likely to occur.

Case 12 is not practical for the same reason as given in case 4.

The last four cases are those in which both potential and current vary. They are hardly practical cases, because electrical distribution is almost always either at constant current or constant potential. It is, however, of course, possible to have cases where both may vary, and examples of each case are given.

Case 13 is one which does occur to a certain extent in practice; for example, if a so-called constant current circuit varies slightly, as it always does in practice, say from 9 to 10 ampères, then the current as well as potential is variable to that extent, and this must be taken account of in the regulation.

In the experiments which I have already referred to, Mr. Wheeler and I have built a motor of the constant current type which will govern for wide variations in current as well as in load. This motor, for example, will not fall in speed, even though the current be reduced from 10 to 5 ampères, which is a great variation for this type of motor, as the field and armature being in series, the torque varies as the square of the current. This variation in current in the so-called constant current circuits is a much greater percentage than the variation in potential of so-called constant potential circuits, and amounts to ½ to 1 ampère.

Having generally described the different cases of motor regulation, let us take up the mathematical relations of potential current, speed and load, which may be expressed quite simply.

Using the symbols P, C, S and L, as defined above, we have $P \times C$ as the total electrical energy supplied to motor in watts, or $\frac{PC}{746}$ in horse-power. Calling commercial efficiency, *a*, the actual mechanical horse-power developed by a motor is $\frac{aPC}{746}$ expressed in electrical terms. The equivalent expression in mechanical terms is $\frac{2\pi SL}{33{,}000}$. Since the point at which load L is measured is 1 foot from centre of shaft and travels 2π feet per revolution, or $2\pi S$ feet per minute. This, multiplied by the load and divided by 33,000, gives the horse-power developed by the motor.

Thus we have:

$$\frac{aPC}{746} = \frac{2\pi SL}{33{,}000} = \text{H.P. of motor}$$

or

$$PC = \frac{746 \times 2\pi SL}{33{,}000 \times a} = \frac{SL}{7{\cdot}04 \times a}.$$

For convenience we may write $PC = \frac{SL}{7a}$ with an error of about one half of one per cent.

If the efficiency, *a*, of motor is 85·2 per cent. the denominator, or $7{\cdot}04\,a$ becomes 6 exactly, and we have $PC = \frac{SL}{6}$ and if the efficiency is 75·8 per cent. we have $PC = \frac{SL}{5}$. The former is as high and the latter is as low as is ordinarily met with in practical work; therefore, these are the limiting values.

The equation $PC = \frac{SL}{7{\cdot}04\,a}$, or one of the three simplified forms just given, may be advantageously used for solving problems in motor regulation. If we know any four of the quantities we may, of course, find the fifth by simply solving the equation with respect to it. It is also evident that if any three of the quantities are constant, then the other two will vary directly or inversely with each other, depending upon their position in the equation. This is the ordinary case we have to deal with in regulation. Usually speed is required to be constant, either potential or current is maintained constant, and efficiency should be practically constant down to very small loads; thus we have either current or potential or load varying directly with load. The efficiency is rather a confusing element in motor regulation. For this reason it was not introduced as a fifth quantity in the second table, as it would have complicated it and made a great many more possible cases. The efficiency should be high (close to 100 per cent.) and as nearly as possible constant, therefore it would not affect the figures much.

If the load or speed is zero or very low the potential or current should be correspondingly reduced, and the efficiency would remain constant. This is the condition for perfect regulation. Practically it always takes some current to overcome friction, &c., even when load is zero, in which case efficiency is zero; but this current should be very small.

The equation $PC = \frac{SL}{7{\cdot}04\,a}$ applied to the cases marked "not practical" in second table, shows in Case 4, for example, that if PC and L are constant, the efficiency, *a*, decreases directly with reduction in speed. This is not allowable. The same is true of the other cases, and shows that it is not proper to vary P, C, L, simply at the expense of efficiency; or, in other words, waste current, to obtain regulation.

Having now given the general points of motor regulation, we will consider the forms of motors which are now being used extensively.

First and most important, we have the regular shunt motor for constant potential circuit, which has already been referred to several times. Thousands of this type of motor are in use, and give very satisfactory results. A properly designed motor of this kind will regulate within 5 per cent., which is near enough for most purposes. It has no regulating mechanism or complicated circuits to get out of order, and it may be called the ideal self-regulating machine. The next important form is the differential wound motor, which is even more perfect in closeness of regulation, theoretically, and it might be made almost absolutely constant in speed; practically the speed varies about 2 per cent.

These are the figures given me by the company who manufacture these machines in the largest quantity and of the most excellent workmanship. Silvanus Thompson gives an example of one of these machines, which only varied ½ per cent. in speed, with a variation from 1·1 to 11·14 H.P.

The rule for winding differential motors is that the number of turns in the shunt divided by the number of turns in the series coil are equal to the resistance of the shunt divided by the resistance of the armature plus the resistance of the series coil. On this side of the Atlantic this is called Sprague's law of winding; on the other side it is called Ayrton and Perry's rule for winding. The slight variation in speed which does occur is due to the heating of the two coils and other slight disturbances. The shunt coil varies considerably in resistance effected by heating; therefore the series coil should have a few less turns than the rule requires. The heating of the shunt coil weakens the current in it, and consequently the field magnetism, thus increasing the speed of the machine, therefore the motor runs faster after it has been running for some time. The proper way is, of course, to consider the true speed to be that which the motor has in steady running. At first, some trouble was experienced in this type of machine on account of short-circuiting between the series and shunt coils, but this has been overcome by more perfect insulation.

The shunt or differentially wound machines may be varied in speed by putting resistance in the field circuits, as shown in fig. 1. This may, of course, be done automatically, or by hand, usually the latter.

The next important type of machine is the constant current motor. As already stated, this is merely a series wound machine, with switch for cutting in and out the field coils, the latter being operated by an automatic centrifugal governor, as indicated in fig. 3, or by hand. Various modifications of this type have been made—for example, a reversed coil may be wound on the field magnet coil and having a variable resistance in circuit with it. If this resistance is very high the reversed coil has little or no effect. If this resistance is made very low it will rob the main coil of its current, and also neutralise its effect, thereby greatly reducing the strength of the field magnet. All these motors with varying field strength have the drawback that a certain time is required for the magnetism to vary, and the regulation is therefore sluggish. If we attempt to hasten this by laminating the field core we have sparking at switch points, due to self-induction in field coils.

Constant current machines with regulator are now in great demand for arc circuits; in fact, it is not practical or safe to use a motor on an arc circuit without a regulator, as the danger of racing away is very great.

The differential winding of constant current motors to maintain constant speed is not practicable. The solution of it requires either that the efficiency should be very low, or that storage batteries be used in connection with the motor to maintain a constant difference of potential. Any such plan as this is, of course, very objectionable.

The three types just given are really about the only continuous current motors, used to any extent, in practice, and it seems that there is at present no demand for any other type.

Nothing has been said of the regulation of alternating current motors, because it is a radically different subject, and, moreover, alternating current motors tend to run synchronously, maintaining a constant speed and regulating themselves.

In conclusion, I would say that I would like to see this subject taken up by leaders in electrical science and given the attention which I think it deserves.

RECEPTION OF AND DINNER TO PROF. ELIHU THOMSON.

THE work accomplished by, and the high scientific attainments of Prof. Elihu Thomson, are well known and appreciated throughout the civilised globe. From his vast practical experience as an engineer in the development of his numerous inventions, and more especially in bringing to perfection the Thomson-Houston system of electric lighting, in which electrical as well as mechanical difficulties of no light order have been surmounted with a skill and success almost unprecedented, the Professor is recognised by the public at large as an inventor and an exponent of certain electrical machinery. But the world of professional science is aware that laboratory work is most congenial to his mind; that he is heart and soul in experimental and inductive processes, and that to follow up to its unknown source some side glimpse of thought, tending possibly to further revelation of nature's mysteries, give him more delight than the bustle and din of work-a-day life in the large manufactories that produce in mechanical form the teeming offspring of his brain.

With all his striking record of scientific and practical achievements, of which he may well be proud, we never recollect meeting a man of more modest or unassuming manner, nor one better qualified to fulfil any duty thrown in his path, even to the not always desirable one of making speeches.

Born in Manchester, we believe, we can claim the Professor as one of ourselves by birth; but proceeding with his parents to the States at the early age of five years, his education and life have been entirely

American; his onward progress has been one of uninterrupted success. When quite a lad he assisted Prof. Houston, and without doubt his after life would have been spent in pure professorial work, had not electric lighting been on hand to induce him to throw his abilities and energies into a more practical channel. English by birth and parentage, we feel sure that his American *confrères* will not begrudge us a share in the honour his brilliant talents have conferred on his adopted country, nor in the privilege of welcoming him to the old country once more as a long absent brother. Stranger he could never be, his numerous inventions and his scientific papers have made him familiar to all and every one of us.

The close affinity of the Laing, Wharton and Down Construction Syndicate with the Thomson-Houston Company (its *raison d'être* being the extension of the Thomson-Houston system of lighting) rendered it natural that they should seek to welcome the Professor on his arrival in England, and this welcome took the form of a reception and dinner on Wednesday evening at the Ship Hotel, Greenwich. Colonel Martindale, C.B., late R.E., chairman of the finance committee of the syndicate, occupied the chair, and was supported by Mr. Percy Westmacott, Dr. Merz, and Mr. Crewdson, members of the committee; and by Messrs. Wharton, Down, and Davies, the syndicate's expert managers; and Mr. Warine Martindale, the secretary.

Among the guests met to do honour to the Professor were: Sir William Thomson, F.R.S.; Sir Frederick Abel, C.B.; Profs. George Forbes, John Perry, Silvanus Thompson, Ayrton, and Hughes; Captains Candee and Holden; Doctor J. A. Fleming; W. Lant Carpenter, and J. T. Moulton, Q.C., M.P. Some others of our leading electricians were unable to accept the syndicate's invitation.

The Professor was received on his arrival by a few words of welcome from the chairman, and was followed by Sir William Thomson, who, after some brief remarks as to the researches and achievements of his namesake, lamented the comparative slowness of electrical progress in this country, and that we would welcome American go and enterprise here, without the faintest jealousy, in friendly rivalry with ourselves; and the more the two people were brought in contact with one another, the more friendly and brotherly they would become.

Sir Frederick Abel and Mr. Swan said a few words, and Prof. Elihu Thomson, in reply, remarked that he thought the more fruitful production of inventions carried to success in America was not that the people were absolutely more inventive than the people of this country, but that it was a result of the different soil. Necessities arose in the States which had to be overcome; in surmounting these, inklings were given that speedily were developed into something tangible from which a useful invention would spring, to the advantage of all people. Opportunity made the mind turn to a subject and thresh it out. Without the opportunity the mind was dormant, and hence the greater fertility of American inventors over their European brothers.

The toasts proposed by the chairman were the Queen, the President of the United States, Prof. Elihu Thompson; prosperity to the Thomson-Houston system was given by Dr. Merz; and "Our Guests" by Mr. Wharton. The professor returned thanks, Mr. Meech, of the Thomson-Houston Company, replied on their behalf, and Mr. Moulton, Q.C., for the guests.

The New Telephone Company.—A notice appears in our advertising columns inviting purchasers of this company's telephones to communicate with a solicitor at Sheffield with a view to testing the action of the company's directors. It is hoped that all who feel themselves aggrieved in this matter will comply with the request, as there seems to be good ground for hoping that combined action would result beneficially to the holders of the company's guarantees.

NOTES.

The Electric Light in Brighton. — The General Purposes Committee report, with reference to the application by the Brighton Electric Light Company, Limited, for a Provisional Order under the Electric Lighting Acts, 1882 and 1888, to authorise them to supply electricity for public and private purposes in Brighton and Hove, that the local inquiry appointed by the Board of Trade was held before Major Marindin, C.M.G., R.E., on the 11th and 12th days of April last, at the Town Hall, Brighton, and that the Corporation were represented at the inquiry by Mr. W. P. G. Boxall. After the termination of the inquiry, which was reported in the REVIEW, some correspondence ensued between the Board of Trade and the Mayor, in the course of which his Worship informed the Board that it is the intention of the Corporation "to take the necessary steps to put in operation the powers under their Order of 1883 as soon as there is a satisfactory system available which they can adopt with reasonable confidence that it will not shortly be superseded by new inventions," and the Board wrote enquiring "the probable time within which the powers conferred upon the Corporation by their Order of 1883 will be put into force." Upon the receipt of this enquiry the Mayor submitted the correspondence to the committee, and requested their opinion as to the reply to be given to the Board of Trade, and the Town Clerk, by direction of the committee, informed the Board that the Corporation will commence operations under their Order within two years from the present time. The decision of the Board of Trade upon the company's application has been communicated to the Mayor in a letter dated May 29th last, in which the Board state that they have informed the agents for the promoters that "as it appears that the Hove Commissioners and the Brighton Corporation are prepared themselves to undertake the supply of electricity to the inhabitants of their districts, the Board of Trade do not feel justified in dispensing with the consent of those authorities to the granting of the Order." The effect of this decision is that the company's application cannot be further proceeded with. It will be necessary for the Town Council to take steps at an early date to put in operation the powers conferred by the Order of 1883. This may be done by the council either themselves constructing works, employing a staff, and laying mains for the purpose, or by contracting with a company to furnish a supply of electricity within the borough.

The Electric Light at Teddington.—Lord Dysart is having the electric light installed at Ham House, Teddington. This house is one of the most interesting houses in England, and has scarcely been touched since the Duchess of Lauderdale—whose husband was the "L" of the Cabal Ministry—diverted herself in its splendid galleries and stately chambers.

Electric Light at Benthen.—A nice little dispute has been going on at this German town. Messrs. Lier and Stern applied to the municipality for power to lay down cables for the supply of the electric light. The gas company of Silesia, which owns the gas works at Benthen, claimed that this was an infringement of the monopoly of laying gas mains, and held that if cables were not mentioned in the agreement it was simply due to the fact that electric lighting was not then in existence. What they maintained was that their contract gave the sole right of lighting in the town. In order to give satisfaction they are prepared to lower the rates and light some of the best streets with the latest improvements in lamps and burners. In case any discontented individuals want more than this, they will even establish a central electric lighting station. It appears, however, that the municipality does not look upon the matter in the same light as the gas company, nor does it read the agreement in the same manner. The question is so far unsettled.

The Leading Light at the Asylum—Gas or Electricity.—The Asylum Board of Dundee, at their last monthly meeting, Provost Scott in the chair, discussed the advisability of introducing electricity to the Asylum. Mr. Ross, convener of the house committee, submitted a report by Mr. William Bryson, Glasgow, on the eight tenders received by the committee. Mr. Bryson said, in so far as he considered, the lighting of the Asylum would be safer if two dynamos were used to generate the current, and he specified two offers which he thought would be preferable. He suggested the employment of two engines driving the dynamos direct without any counter-shafting, with a boiler of large steaming capacity. He submitted a detailed estimate of the cost of lighting the whole institution (including the new hospital), which amounted to £317 per annum. Mr. Ross said Mr. Bryson had calculated that new lamps would be required every year, but that was not the case over the whole building, as many of them would only be used occasionally. Mr. Bryson had put down full wages for a man, but that expenditure would be modified very considerably. It was pretty clear that there would be a saving by dispensing with the gas; but at the same time the question was mainly one of sanitation, and he thought that was the ground on which the meeting should decide the matter. In answer to Mr. W. D. Johnston, Mr. Ross said the present cost of gas was £270, and when the new hospital was finished it would probably amount to £356. The committee did not propose to dispense with gas entirely, but to retain it in the bed rooms.

The Electric Light in Collieries.—The electric light is now used at the Llay Hall Colliery, Gwersyllt, for the first time. There are 65 lights at this place, some 16 and some 32 candle-power, lighting the pit head, yard, crossings, offices, and workshops.

Railway Station Lighting.—The station of Esschen, on the line between Antwerp and Essendael is being lighted electrically instead of by petroleum as hitherto. There are 10 arc lamps, six of 12 ampères and four of 8 ampères. A Dulait dynamo is used, capable of supplying a current of 150 ampères and 70 volts. It runs at a speed of 460 revolutions per minute. A second dynamo of the same power is kept as a reserve and will furnish current to other lamps when extensions are carried out. Messrs. Carels Frères, of Ghent, have supplied the steam engine, which is of the horizontal type, and the boiler employed is a tubular Laurenz boiler.

Electric Lighting in Llandudno.—Llandudno Pier and Pavilion were lighted with the electric light for the first time on Saturday evening.

Copper Depositing.—Elmore's Foreign and Colonial Patent Copper Depositing Company, Limited, has this week been brought out in order to acquire the foreign Elmore patents. It may be recollected that some little time ago an English company was brought out for acquiring the English patents, which was subscribed for nearly four times over. We give some particulars of the trials abroad in another column, and it is enough to say that Messrs. Woodhouse & Rawson, Limited, are connected with the new company to explain the fact that the capital has been over subscribed, the shares having been dealt in at from 1 to $1\frac{3}{8}$ premium during the week. The company that acquired the English patents has just been granted a settlement and quotation on the Stock Exchange official list.

How are the Mighty Fallen!—The Hell Gate electric light tower, which was erected by the American Government in 1883 at a cost of $20,000, has been doomed to the scrap heap. The electric glare was not beneficial to navigation in this instance.

Cui Bono.—All the letters of allotment and regret in the Electric Construction Corporation, Limited, have now been posted, but we understand the founders have been "stuck" with four-fifths of their shares.

Electric Lighting in Leeds.—There is now under consideration by the Electric Lighting Committee of Leeds a comprehensive scheme for the lighting of the central parts of the town, so designed as to be extended to meet all reasonable demands. In a few days, or weeks at most, the whole question, in detail as well as principle, will be thrown open for discussion in the Press.

Medical Treatment by Electricity.—The *British Medical Journal* for June 8th contains an article by Dr. Thomas Keith on the treatment of uterine tumours by electricity, in which the necessity of great care during the time that electrical treatment is being carried on, especially when negative electricity is used, is pointed out.

Musicians and Electricity.—When Berlioz introduced the use of electricity to produce certain effects at a distance, he did not think that it might be the means of depriving other musicians of their bread. To work several organs in various parts of the town from one keyboard might be economical as regards labour, and might be useful for evening entertainment in public halls; but to go a little further and supply all the churches from a common centre would raise much outcry from the suffering race of organists, who would fear being sent to swell the noble army of unemployed —at any rate, as far as Sunday is concerned. Some persons may imagine that this means of supplying churches with music would do more to bring the church services to one standard than all the "Acts of Uniformity" that were ever passed. This is not the proposition. The idea is to have at the central station players and instruments to suit all denominations and creeds; wires to be laid to the several churches or meeting-houses in the same manner as for the telephone service. Should this scheme be carried out in its entirety, we do not think that musicians will be the losers to any great extent, and there would be this advantage, looking at the question from the church-going public's view, that to fit the music in with the church services, it would be necessary that everything be conducted with regularity in the matter of time, and in consequence sermons would have to be of a uniform length, whereby a prosy parson's discourse would be reduced to moderate proportions, to the evident benefit of his long enduring listeners. If the French saying is at all correct, that "England is a country of a thousand religions, but of only one sauce," musicians will have no cause to fear for their livelihood, while congregations will proceed on their homeward way with a good temper to enjoy that one sauce and peace will still prevail. The only danger to be anticipated would arise from carelessness on the part of the attendant at the central exchange, or from an accidental cross, by which a portion of, say Mozart's Twelfth Mass, might be sent to some ultra-Protestant conventicle. But even this mistake would not be unmixed with good. Food for gossip would be spread, and the excitement would improve the health of all the old ladies in the parish, and the latter would possibly say that electricity had been pressed into the service of the evil one.

A New Atlantic Cable.—A Brussels correspondent states that it is proposed to lay a submarine cable from Ostend to America.

New Cable.—The *Financial News* learns that the Telegraph Construction Company has signed a contract for laying a cable direct from Europe to Buenos Ayres. The Government of the Republic guarantees 5 per cent. to the shareholders. The number of messages now sent through the Brazilian Submarine and the Western Brazilian to the territory of the Republic is said to be sufficient to pay at least 4 per cent. on two millions sterling. A new company will be started to take up the contract. The Telegraph Construction will be the vendors, and Sir John Pender the chairman.

Anticipated Crime Galore.—A Central News telegram from New York states:—The American Executing Company has just been incorporated at Chicago with a capital of 25,000 dollars. It is started to take over from the Sheriffs, as a going concern, the execution of criminals throughout the States, and the promoters say that those taking up shares may reasonably expect a good dividend.

The Late Thunderstorms.—The late thunderstorms seem to have been particularly noticeable in that all the phenomena which at one time or other accompany such outbursts were observed. Chain, ball, and other forms of lightning were all noticed; to summarise the damage done would occupy a considerable space, as reports come from all parts of the country of human beings and cattle struck and killed, &c.

How She is Worked.—The other day the electric launch, the *Ray Mead*, was lying alongside a well-known hostelry, where the waiter, who had never seen an electric launch before, exhibited considerable curiosity as to her motive power, and surmised in the owner's hearing that she went by clockwork. The proprietor was equal to the occasion. "She does go by clockwork," he said, "but the machinery has run down. Get me a clock key and we will start her again." A key was promptly procured and the vessel, having apparently been wound up, proceeded on her way to the admiration of all beholders.

Electric Fire Engine.—Mr. Ruther, of Bridgeport, Conn., U.S.A., proposes to substitute for steam fire engines, in large cities where electrical services are prevalent, engines driven by electro-motors supplied with current from mains whose terminals are placed in boxes adjacent to each hydrant throughout the city.

Institution of Civil Engineers.—At the recent annual general meeting of the corporate members the ballot for council and officers resulted in the election of Sir John Coode as president; of Mr. Berkley, Mr. Hayter, Mr. Giles, M.P., and Sir Robert Rawlinson as vice-presidents; and of Mr. Cowper, Mr. B. Baker, Sir James N. Douglass, Mr. J. W. Barry, Sir Douglas Fox, Mr. Preece, Sir E. J. Reed, M.P., Mr. Mansergh, Mr. Anderson, Mr. Charles Hawksley, Mr. Shelford, Mr. Lyster, Mr. F. W. Webb, Mr. J. Clarke Hawkshaw, and Sir Bradford Leslie as other members of council. The past presidents in order of seniority are Sir John Hawkshaw, F.R.S., Sir John Fowler, Sir Charles Hutton Gregory, Mr. T. Hawksley, Mr. G. R. Stephenson, Mr. J. F. La Trobe Bateman (just deceased), Mr. W. H. Barlow, Mr. James Abernethy, Lord Armstrong, Sir James Brunlees, Sir Joseph William Bazalgette, Sir Frederick J. Bramwell, Mr. Edward Woods, and Sir George B. Bruce.

Reward for Bravery.—At a public meeting of the citizens of Waterford, held in the Public Hall on the 9th inst., the mayor, Captain Toole, presiding, the medal and certificate of the Royal Humane Society were presented to Mr. William Croker, of the Waterford Postal and Telegraph Department, for his bravery and heroic conduct in saving from drowning in the River Suir, at the risk of his own life, a lad named Pennington.

Othello's Occupations Gone.—A coloured chap, named Newkirk, hailing from under the Hurley Mountain, was in Kingston, N.Y., circulating a petition recommending him for the position of "Blower out of Electric Lights." Some joker had told him that the city wanted a man to climb the poles at 2 o'clock every morning and blow out the lights, and that a well-recommended person could get the job.

Electricity and Gas.—The Société Technique de l'Industrie du Gaz en France is holding its annual general meeting this week at the exhibition. The programme gives a sign of the times, for among the papers is one by Monsieur D. Monnier, on the central station of the Palais Royale and on electrical mains; Monsieur E. Hospitalier reads a paper on electricity meters; Monsieur Lechatelier on pyrometers, and Monsieur Ph. Delahaye on the profits of electrical stations. This is rather an amusing programme for a gas congress.

A Bad Case.—We have on more than one occasion had to draw attention to the abuse of the word "electricity" which was being made by quack doctors. One of the most audacious and impudent exploits in "medical electricity" was made at St. James's Hall on Wednesday night, when an individual whose name is well known in connection with a recent lawsuit, professed to cure almost instantaneously all sorts of diseases. The performance began by a long oration by his manager, who explained that life and health depend upon the normal flow of certain invisible currents which may be thus classified and named:—The electro ossific current which permeates the bones; the electro muscular which permeates the muscles; the electro nervous which permeates the nerves; and the electro intellectual which permeates the brain. After this, electricians whose knowledge runs only in the way of continuous and alternating currents, will have to sing small. The lion of the evening, who it was announced was about to become a naturalised Englishman (though this country could well spare him), then appeared, and gave shocks to a few people from a battery out of view of the audience. This done, electricity vanished from the field. From one corner of the hall there turned up in rapid succession the blind, and deaf, and halt and dumb. Each was placed in a chair, rubbed about a little, and each went off professing himself cured. A man who was represented as unable to walk on to the platform, departed quite briskly. Where the electricity came in was an not explained. It is deeply to be regretted that such exhibition should be advertised as curing by electricity. There was a large attendance of chuckers-out, and part of the audience would have confirmed Carlyle in his opinion that the majority of the population of Great Britain were fools. It is unfortunately the case that those most liable to be taken in by quack electricity are the very people who never have an opportunity of seeing electrical journals in which the methods adopted are exposed, but we are extremely glad to see that the *Evening News* of yesterday falls foul of the exhibition in a very unmistakeable manner. A few daily papers with similar courage and good sense would make this electropathic quackery a thing of the past.

A Word of Advice.—The following letter which arrived too late for our correspondence columns will be read with interest:—"It is much to be hoped that the confusion from which acoustics and optics have recently escaped, is not about to settle upon electricity. In the former sciences "period" or "wave" refers always to the complete cycle of changes, and the number of complete periods in the unit of time, say, one second, is (after Thomas Young) often called the "frequency." The same terminology is applicable to electrical vibrations. The period, or the periodic time, will of course cover one positive and one negative part, and in like manner the "periodic frequency" will mean the number of periods per second. When the usage is well established, it may be possible to drop the qualifying "periodic" and to speak simply of frequency; but in electricity there may be at first some danger lest the frequency of alternating currents should be taken to mean the frequency of *alternation*. For this reason it will be prudent for the present to speak always of *periodic frequency*.—RAYLEIGH; WILLIAM THOMSON."

The Birmingham Electrical and Industrial Exhibition.—We hear that the space for the exhibits in the Electrical and Industrial Exhibition (International), to be held in Bingley Hall this year, has all been taken up, and that the preliminary arrangements have been settled in a most satisfactory manner. It is interesting to find that Birmingham has been well represented in the various pioneers of the now rapidly developing science of electricity. The original dynamo or electro-depositing machine, which will be shown in the Exhibition, was invented by a Birmingham man, and built in the works of Messrs. Prime and Sons, the well-known electro-platers. An interesting collection of electric lighting apparatus, including one of the early incandescent lamps, is being sent over by Dr. Woodward, of Toronto, who was born in Birmingham. It is said that Dr. Woodward's inventions were sold to Mr. Edison at the time he commenced to bring out the system of lighting, which has since become so popular. The contract for erecting the boilers, engines, and other foundations, the orchestra, and the general works connected with transforming Bingley Hall into a fitting home for the Exhibition has been let to Mr. John Parkes, Conybere Street, and the works will be pushed forward with all possible despatch. It is intended to open the Exhibition on Thursday, August 1st, and arrangements have been made with the leading railway companies in the kingdom to run excursion trains at frequent intervals, to give an opportunity for people at a distance to visit the Exhibition at a low charge.

Executions by Electricity.—The first person to be officially put to death by electricity is Kemmler, the first person convicted of murder under the new law. The sentence is to be executed at the Auburn (New York) State Prison. The death warrant, recently signed, directed that the sentence be executed "upon some day within the week commencing Monday, June 24th.

Had it a Lightning Conductor?—A telegram from New York, dated the 12th inst., states that St. James's Cathedral, Brooklyn, was struck by lightning and destroyed. It is desirable to know whether it had been provided with any protection against the effects of lightning.

Electrical Atmospheric Conditions of Large Towns.—It is stated on the authority of a Parisian physician, that the electrical atmospheric properties of the French capital have been quite upset by the Eiffel Tower. Precise details are, however, still wanting to show in what manner this has been made possible.

The Lighting of Battlefields.—A French contemporary gives us the particulars of some experiments which have been carried out at Val-de-Grâce with a new lamp destined to facilitate the search for the wounded on the field of battle. This lamp is nearly as large as those placed on the front of locomotives. It has a powerful reflector, and the light is produced by the combustion of two magnesium wires. Unfortunately, the lamp is very heavy, and the clockwork movement which allows the magnesium wire to unroll appears very fragile for an apparatus destined to be carried about during a campaign. For these reasons, M. Colin, Medical Inspector-General, M. Dujardin-Beaumetz, Director at the Ministry of War, and the officers of the artillery and the staff, who were present at the experiments, were not able to come to a decision before making further experiments.

Telegraphic Communication with Coastguard Stations.—At the monthly meeting of the council of the Incorporated Chamber of Commerce of Liverpool, the proceedings of the General Trade Committee showed that a letter had been received from Sir George Baden-Powell, stating he was about to bring forward a motion in the House of Commons with respect to the above subject. The support of the chamber was solicited. Lord George Hamilton stated, in reply to a question put by Sir G. Baden-Powell, that out of 740 coastguard stations around the coasts of the kingdom, only 325 are within a mile of an electric telegraph station. Sir G. Baden-Powell has been invited to give details of his scheme.

It is stated that great pains have been taken by the Intelligence Department to ensure that this year all the coastguard stations shall be in telegraphic communication with one another by the time the manœuvres take place, and consequently with the Admiralty. This will materially alter the conditions of the fight, and must be borne in mind when praise is awarded to the winning side.

NEW COMPANIES REGISTERED.

Scottish Automatic Supply Company, Limited.—Capital, £12,500 in £1 shares. Objects: To trade as proprietors of automatic delivery, weighing and electric machines, and to take over the business carried on by Alfred Barrett and C. A. Barrett in various places, under style of the Sweetmeat Automatic Supply Company. Signatories (with 1 share each): H. F. Knight, Devonshire Chambers, Bishopsgate; C. H. Banyard, Westbourne Park Crescent; Wm. Barrett, Brentwood; H. T. Moore, Kynaston House, Tottenham; T. H. Dixcee, 190, Stanstead Road, Forest Hill; R. Lucas, 8, Cromwell Crescent, S.W.; H. Fowlein, 1, Copthall Chambers. The subscribers are appointed directors until the first general meeting. Qualification, £100 in shares. Remuneration, £50 per annum each. Registered 5th inst. by George Tilling, Devonshire Chambers, Bishopsgate.

Municipal Electric Light and Power Company, Limited.—Capital, £25,000 divided into 2,490 ordinary shares of £10 each, and 100 founders' shares of £1 each. Objects: To generate, distribute, supply or use in any manner, electric or magnetic currents for light, heat, motive power, force, storage, deposition of metals, means of communication, and other purposes. Signatories (with 1 share each): A. Aylard, Manor Park, Essex; F. W. White, 30, Crewy's Road, Peckham; Wm. Grey, 11, Tessington Street, S.E.; E. R. Day, 22, Canonbury Road, N.; F. E. Julian, 36, Powell Road, Clapton; M. J. Sleet, 75, Shrubland Road, Dalston; E. C. Laming, 33, Lewisham Road, S.E. The signatories are appointed first directors; qualification for subsequent directors, 25 ordinary shares; the company in general meeting will appoint remuneration. Registered 5th inst. by Wm. Webb & Co., 6, Essex Street, Strand.

Elmore's Foreign and Colonial Patent Copper Depositing Company, Limited.—Capital, £120,000 divided into 15,000 priority shares of £5 each, and 9,000 founders' shares of £5 each. Objects: To acquire, re-sell and work the foreign colonial patent rights of Francis Edward Elmore and Alexander Stanley Elmore relating to the treatment and electrical deposition of copper and other metals, and for the manufacture of all kinds of metal articles. The signatories (who take priority shares) are as follows: Sir J. H. Morris, 88, Queen's Gate, S.W.; John MacFarlan, Invermay, Wimbledon; Edwd. J. Carron, Surbiton Hill Park, 50 shares each; Fredk. Lawrence Rawson, 11, Queen Victoria Street, 1,150 shares; J. H. Ward, 11, Queen Victoria Street, 1 share; R. J. Jones, Vale of Health, Hampstead, 1 share; Wm. Stepney Rawson, 68, Cornwall Gardens, 1 share. The signatories appoint the first directors. Qualification, 50 shares. Remuneration of board (managing directors excepted), £1,500 per annum until the board exceed seven in number, when the amount is to be £2,000 per annum, together with 5 per cent. of the net profit after the payment of 10 per cent. dividend on the priority shares. Registered 6th inst. by Newman Hays & Co., 31, Abchurch Lane.

Electricity Supply Company of Spain, Limited.—Capital £100,000, in £5 shares, 100 of which are founders' shares. Objects: To form centres in any towns or districts of Spain at which electric power may be generated, accumulated and distributed. Signatories (with 1 share each): Robt. Hammond, 117, Bishopsgate Street; Wm. May, 18, Austinfriars; H. Ernest Warner, Hopton Road, Streatham Common; H. Mann, 12, Woburn Place, W.C.; W. A. Pittman, 7, St. Helen's Gardens, North Kensington; T. E. Towerson, F.C.S., 1, Portland Road, Finsbury Park; H. St. John Winkworth, 22, Clareville Grove, South Kensington. The subscribers are to appoint the first directors, qualification £250 in shares, remuneration £500 per annum, together with one-tenth of the net profit remaining after payment of 7 per cent. per annum dividend upon the ordinary share capital, provided that the whole remuneration shall not exceed £1,000 in any year. Registered 7th inst. by Slaughter & May, 18, Austinfriars. Registered office, 15, St. Helen's Place, E.C.

CITY NOTES, REPORTS, MEETINGS, &c.

Lancashire and Cheshire Telephonic Exchange Company, Limited.

THE eighth ordinary general meeting of the shareholders of this company was held on Tuesday at the Memorial Hall, Albert Square, Mr. Alderman Joseph Thomson, chairman of the directors, presiding.

The directors report and statement of accounts, published in last week's REVIEW, were taken as read.

The Chairman moved their adoption, and the declaration of a dividend at the rate of 8 1-6 per cent. per annum for the ten months ending 30th April.

The motion was seconded by Mr. Eli Heyworth, deputy chairman of the company, and adopted.

The Chairman said there was an old saying that union was strength, and the Lancashire and Cheshire Company in company with the other telephone companies of the kingdom had for some time back felt that they would be in every way much better off if they were to be united on equitable terms. As shareholders of the Lancashire and Cheshire Company their first thought very properly was as to how the change would affect the value of their property, and of course it was the duty of the directors to try to make the most of the shareholders' property. The directors had come to the conclusion, after very careful thought, that in every way it would be advantageous to the Lancashire and Cheshire Company to amalgamate with the other two companies—the United Company (the parent company) and the National Company. The reasons for this were manifold, but he would only mention one or two of them. In the first they thought the amalgamation would result in the reduction of the working expenses by a very considerable amount. In the second place they thought there would be the advantage of having the opinion of skilled persons who had given their thought to telephonic development, and who represented different portions of the country; and they thought that by amalgamation they could work together profitably as one board. Then they thought the adoption of the proposal would result in developing the telephonic system very largely indeed. Their company had already an extensive trunk system in the two counties, and the directors believed that with the march of science the time was not far distant when telephonic messages might be easily sent to great distances. It would be manifestly advantageous for the Stock Exchanges of our great centres of population to be put in telephonic communication one with another. Then the shareholders had also to look at the matter as one of self-interest. The intention of the three companies in their union was to have formed a new company, and this new company was to buy up the three existing companies, and probably, by-and-bye, to buy up the subsidiary companies. Everything was arranged between the three companies, but at the last moment the Postmaster-General declined to grant a licence to the new company. Before he went further perhaps he might say that they had spent 12 months in trying to come to a basis of agreement. It was thought at first that the best way would be to submit the books of the three companies to a first-class firm of accountants, and in that way ascertain on what terms each company should be taken in. But after 12 months of labour they found that they were no further forward than they were before, and the directors began to think whether there was not a better way. Mr. Charles Agnew, one of the directors, suggested that the fairest and simplest way would be to take the market value of different stocks on a certain date. That idea was also broached in London, and it was ultimately adopted. But when everything had been arranged on this basis, the Postmaster-General was approached, and was asked if he would grant a new licence. This he distinctly refused to do, and for a time it appeared as if they were to be baffled in their efforts. But the solicitors looked into the matter and found that there was full power for any one of the existing companies to absorb the other two, and the company which was thought to be the most suitable to do so was the National Company. That company had a good name, and it covered the whole country. It was also in favour of that company absorbing the other two that the par value of its shares was £5, and the market value only £6, whereas if the United Company had been taken as a standard, their shares, which stood in the market at £15, would have had to be reduced to £5, because £5 was the nominal value. The nominal value of the Lancashire and Cheshire Company's shares being only £1, they were in a worse position than either of the other two. It had since been arranged that the agreement should be so far modified that the market value of the shares should be reduced by one-sixth—that the United Company's should be taken at £12 10s., the National Company's at £5, and that the Lancashire and Cheshire Company's, which stood in the market at £1 11s. 4d., should be reduced to £1 6s. 3d. Although that seemed to be a reduction in the value of the shareholders' property, it was not so in reality. Although it decreased the nominal amount, it increased the dividend on the shares, and the moment it was known on the market that the shares were earning a larger dividend they would go up to the old value. Therefore, when it was suggested that the value of the share should be reduced to £1 6s. 3d., it was only a nominal matter, and they would get the full value of their shares if they wished to sell. He had no doubt they had seen that the Postmaster-General had expressed dissatisfaction with the action of the companies in this matter. It would almost seem as if they existed on sufferance from the Post Office. The Postmaster would not allow them to transmit the cotton market from Liverpool to Manchester, and he would not allow their athletic friends to telephone the result of a cricket match from Old Trafford to Manchester, because to do that was to transmit news, and the Post Office derived a certain revenue from that source. But surely that was, after all, crippling a legitimate business. The telephone companies did not exist on sufferance from the Post Office, which did nothing to develop their business. It only gave them a licence to work, and for that it exacted from them a large royalty. He found that the three companies about to be amalgamated paid to Her Majesty £35,000 a year in royalties for which the Post Office did nothing at all except to send their clerks to examine the telephone companies' books to see that the companies did not cheat. In return for what they contributed for the revenue they had got a letter from the Postmaster-General, saying that he disapproved of the scheme. The companies, after all their trouble and outlay, were entitled to fair consideration, and ought not to be treated in the manner they had been. The *Economist* of June the 8th spoke of the scheme of amalgamation as one directly hostile to the public interests, but the promoters of the amalgamation maintained, on the contrary, that it would be advantageous to the public. As a trading company, their property depended on how the public were satisfied with the manner in which they served them. He did not hesitate to say that by amalgamation they would have larger capital at their command to develop their business, and their endeavour would be to serve the public as well in the future as in the past. A number of their patents would soon lapse, and competition might be started, so that it behoved them to set their house in order, that when the patents lapsed the public might not want to go to some other company. Let it be remembered that they were liable to competition at any time. There was nothing to prevent any other company starting provided they could get a licence from the Post Office. Under amalgamation they would not have so much to fear from competition. He thought they would be able to reduce their charges by-and-bye, and to render the public more efficient service in the future than they had done in the past. Certainly it was the wish of the directors to make the service as cheap and efficient as they possibly could. He concluded by moving a resolution in favour of amalgamation on the terms indicated.

Mr. Eli Heyworth seconded the motion, which was unanimously adopted.

Thanks to the directors concluded the proceedings.

The Western Union Telegraph Company.—The directors of this company have declared a dividend for the past quarter of 1¼ per cent.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ended 7th June, amounted to £4,68

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending 7th June, 1889, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,220.

ELECTRIC LIGHTING IN LONDON.

THE BOARD OF TRADE AND THE COUNTY COUNCIL.

THE subject of electric lighting in London came up for consideration last Tuesday week at the London County Council (Lord ROSEBERY in the chair) upon the following paragraph in the report of the Highways Committee :—

"Your committee have considered the various electric lighting schemes of the present session, and, in connection therewith, the letter from the Board of Trade which your committee set out in their report to the Council on the 26th of March last, and the objections of the vestries and district boards to the several schemes, copies of which objections were forwarded by the Board of Trade at the request of your committee. They have also had before them reports from the solicitor and Mr. T. P. Gunyon of the engineer's department, on the subject, and a further letter from the Board of Trade, dated 18th May, forwarding copies of Major Marindin's report of the result of his inquiry into the several applications, and asking for the council's observations thereon. The Chairman and some of the members of your committee attended at the inquiry before Major Marindin on several occasions, and Mr. Gunyon was also in attendance as representing the engineer's department. Your committee have very carefully considered the questions relating to the future of electric lighting in London, and have embodied the conclusions at which they have arrived in the form of a letter to the Board of Trade, a printed copy of which has been sent to every member of the Council. They recommend 'That the proposed letter be approved, and sent to the Board of Trade.'"

The letter referred to above is as follows :—

Mr. HAGGIS, in moving the approval of the report and the recommendation that the latter be sent to the Board of Trade, said :—Mr. Chairman,—As the matter to which this paragraph refers—that of electric lighting—is a very important subject, and a matter of great financial and public interest, I think, perhaps, it would be right that I should make a few remarks in moving the adoption of this first paragraph. The Board of Trade addressed a letter to our chairman in March last, in which it was intimated that in all probability before long this Council would be vested with the jurisdictions which the Board of Trade now exercise in regard to electric lighting, and that being the case, they desired to know the opinions of this Council in respect to the many schemes that were then before them for the spread of electric lighting throughout London. Now, the committee having looked at this matter in a very comprehensive way, have approved of a letter in reply to the Board of Trade, and that letter is before the Council now. The Board of Trade in their letter to the Council first of all asked us a question as to the extent of the area which ought to be allowed to any one company. In the applications which have been brought before the Board of Trade at the present time, there are two companies desiring very large areas of supply for London, and the committee, in considering that matter, have come to the conclusion that it is desirable, so long as a company has financial powers to carry out its works and the ability to do it, that we should not debar them in any way, and therefore we are prepared to recommend that a large area of supply should in such a case be allowed. Then we are asked a further question, as to whether we should permit more than one company to come into one district, and so allow competition. As to that, the committee think it is desirable that competition, under proper and reasonable restrictions, should be allowed. The Act of Parliament of last year in one of its clauses clearly shows that Parliament will not allow a monopoly by any one company of any one district, because clause 1 of that Act clearly states that allowing a company to come into one area shall not prevent the allowing another company to come into the same area afterwards, so that no monopoly can possibly exist under that Act. Then the question of the allocation of areas over London to these various companies has been considered in the very lengthened enquiry by the Board of Trade, which took place under Major Marindin. Eighteen days were spent in making that enquiry, and one cannot be surprised that some dissatisfaction has arisen as to the allocation of areas which Major Marindin recommended. Some of the companies feel aggrieved because they are shut out from important, and possibly profitable districts. And others—one company especially—is not allowed to enter any district at all for certain reasons, and a letter appeared in the *Times* last Saturday from Professor Silvanus Thompson, referring to that matter in a very pointed way. But the committee think it would not be wise for this Council to interpose in that matter at all as to the allocation of the areas. We think that as Major Marindin has had this enquiry, and has devoted so much time to the consideration of all the points which were brought before him, it would not be right for us to step in and suggest alterations in the course which he recommends. Therefore we are prepared to agree to the allocations of areas which he recommends. There is one other remark I should like to make, and that is upon the question of overhead wires. We feel that it is of the utmost importance that no overhead wires should be allowed in these large districts. We think they should be prohibited by statute. At the present time the law with regard to overhead wires is in a most unsatisfactory condition. There is no clear law in regard to that matter, and as a result companies have come and placed their wires overhead without reference to public rights at all. I hope that the Highways Committee may be prepared by and bye to bring up a recommendation with regard to that matter, and make some definite proposals as to overhead wires. Major Marindin suggests that where the companies are now working with overhead wires, when they get statutory powers they should place their new cables underground, and that within two years they should remove the overhead wires with which they are now working. That we agree to. But the question of overhead wires is connected very much with that of subways. It is most unfortunate for London that we have no thorough system of subways in our streets. We have very few indeed—in fact, some four miles is all that we have got. It is a question whether it will not be desirable, and in the interests of the public, that before long we should consider this question at the Council with regard to the main streets of London generally—whether it would not be possible for us to make subways, and afterwards that we may compel the companies to use them and to pay for their use. At the present time we are allowing the use of our subways without any charge. We propose that in the Provisional Orders of these companies a clause should be inserted, not only to compel them to use the present subways and pay for them, but also to compel them to place their mains in any new subways that are made. But as that may entail upon them considerable expense, we suggest that for a certain period they should be allowed to use them free, and that afterwards they should pay for their use. Then with regard to the question of price. The Board of Trade have suggested that the maximum charge to be made for electricity should be 8d. per Board of Trade unit. So far as I can ascertain —and the calculations made by experts vary very much—that appears to be something like double the present price of gas—perhaps rather more than double the present price of gas. However, it does not seem certain that electricity can be produced—with fairness to the companies—at a less price than that at the present time. One of the companies was supplying electricity at 7½d., and possibly when they got their statutory powers they may be able to supply it at 7d., but I think it would not be right to put the maximum at the very lowest at which it can be produced, but at 8d. per unit as suggested. (Cries of "Agreed, agreed!") It is suggested also that after seven years the question of price should be reconsidered. That is a matter of the utmost importance. The Board of Trade suggests that after seven years the price should be reconsidered, and that then a sliding scale should be introduced, much the same as the gas companies now have. Now, it may be asked, why is not a sliding scale adopted at once, rather than after an interval of seven years? The reason of that is very clear. If you have a sliding scale now you must fix the initial price, and, as in all probability the result of experience in the course of seven years will enable electricity to be produced at a lower rate than it can be at the present time, it would not, therefore, be right to fix an initial price now, because in that case the companies would get the benefit of any cheapening that might take place in the production of the light. We feel that it is of the utmost importance that during the seven years the companies have a free hand there should be the most full and healthy competition possible amongst them, and therefore every encouragement should be given to them to carry on their work as cheaply as possible. In order to produce that healthy competition, we suggest that no amalgamation shall be allowed or any working agreement between any of these companies during these seven years without the consent of the Council. And we further suggest that if any one company can produce electricity better than another, and can supply it cheaper than another, and if the inhabitants of a parish or district apply to allow that company to come into their district, we shall have the right and the power to consent without going for another Provisional Order. We feel that such an arrangement would put the companies on their mettle, and that it would cause them to do their best to get an increased area. I think if that power were placed in our hands it would materially facilitate the cheapening of the light for the public. Then with regard to the question of price and dividend. The Board of Trade suggest 10 per cent., but my committee think that is too high. When the gas companies had their 10 per cent. fixed some years ago, money was not quite so cheap as it is now, and 8 per cent. now would be fairly proportionate to 10 per cent. of that period, and therefore we say that 8 per cent. should be that upon which this sliding scale should be based. (Cries of "Agreed.") It may be remembered that, according to Act of Parliament, in 42 years we shall have the right to purchase the property of these companies without giving a single penny for the goodwill. That is a very important matter, and therefore we should not be too hard in the conditions which we impose upon them now. The gas companies are not under that regulation at all. (Cries of "Agreed, agreed.") With regard to the question of a guarantee, we think that, like the gas companies, they should have a guarantee from everyone who applies for the light—some suggest £5 per quarter, and others £5 10s. But we think that the minimum charge should be £5, but it should not be for a quarter but for a year, because the consumer under any other arrangement might have to pay for considerably more than he used. I also think this Council should be the controlling authority in regard to all the lighting schemes. It would be a most unfortunate thing for the development of these companies if they were to be subject to various authorities all over London; and it is therefore very desirable in the interests of the science as well as in that of the companies and the public that there should be one controlling authority with the right to control these affairs. We therefore ask that we should be that authority as representing the whole of London. Then we ask, also, that we should have power to inspect their mains and works and to test meters. We also think we ought to be able to enforce any penalties or forfeiture in case of such default. These powers should be placed in our hands, as we feel that it is desirable that these regulations should be made—regulations which are not against the interest of the companies, but in their interests. We desire to see this enterprise prosper; but at the same time it is our duty to safeguard the interest of the public, and on these grounds I ask you to accept the recommendation of the committee.

Mr. LEWES remarked that before the Council resolved to adopt the draft letter to the Board of Trade it was desirable to make one or two verbal alterations, so as to make it grammatical. Mr. Lewes quoted several of the paragraphs which he suggested should be altered, and said he would move that such alterations be made before the letter was sent to the Board of Trade.

Mr. HENRY CLARKE wished to know with regard to the clause which stated, "The Council is of opinion that as the representative governing body of the whole of London it should be appointed the controlling authority," whether the committee had ignored the fact that the Commissioners of Sewers were the authority according to law for the City of London.

Mr. D. H. MACFARLAN said he understood that the Council had been requested to make some suggestions to the Board of Trade. (Cries of "Agreed.") But let them take care that they did not create another monster in the electric lighting companies as had been done in the case of the gas companies. It was suggested that at the end of seven years there should be a sliding scale of prices and dividend upon the basis of a dividend of 8 per cent. He should like to ask whether the maximum had not been fixed at which the public would have the right to purchase.

Mr. H. L. W. LAWSON, M.P., considered it was only wasting the time of the Council to discuss verbal inaccuracies and grammatical points one by one in letters of communication which were brought before them by committees.

Col. ROTTON: Are we in this discussion committing ourselves to anything, or are we only discussing an abstract question which will be brought up by-and-bye in a concrete form?

The CHAIRMAN: You are asked to commit yourselves to the printed letter which is in your hand.

Mr. A. L. LEON: I should like to know if the Council has taken into consideration as to the electric lighting companies for London the question of whether, if the company is one with a continuous current, they would give it permission to occupy the same district that would be occupied by a company working with the alternating current system. With the alternating current you cannot charge the accumulator, and unless there are always a double set of engines going on, and fires being always kept on, there will be a break down. With the continuous current you have accumulators, and I should like to know whether if this letter to the Board of Trade is approved the Council would have the power to do what they liked. It states here in the letter, "The Council is not prepared to offer any opinion or suggestion with reference to the scientific or technical portion of the report, but desires to express its full concurrence with the recommendation in Major Marindin's report that a company supplying a large area without a reserve of current should be required to provide duplicate sets of generating machinery in separate buildings and duplicate sets of mains, in order to secure a proper and continuous supply in case of a breakdown of machinery or other default; and, further, that every possible means should be taken for guarding against danger to the public from currents of high tension." Considering that the expense of doing that would double the capital, it is not likely that the companies would do their work over again, and there is no suggestion made by the committee that the Board of Trade should consider the advisability of adopting some other system than the alternating current, which it is well known is not so satisfactory in all ways as the continuous current is. Therefore, I want to know if the committee have taken that into consideration, and whether they intend to make some suggestions to Major Marindin in respect of it. I would also like the Council to give their special attention to the first clause on page 3 of the letter as follows:—"That clauses should be inserted providing for the application at the end of seven years of a sliding scale of price and dividend on the basis of a dividend of 8 per cent., leaving the initial price and arrangement of the scale to be determined at the expiration of the term of seven years."

Mr. R. C. ANTROBUS said there was a question he should like to put to the committee. They asked that there should be no amalgamation or working agreement between any of the companies without the consent of the Council. He was glad to see that, but still he would like to know whether it was possible that they could propose another power of appeal to the Board of Trade, as he thought it would only be fair to the companies and in their interests that they should have such a right of appeal. The Council must, however, remember that they were the representatives more especially of the consumer. Still, the interests of the companies would be better provided for by having such a power of appeal if necessary to the Board of Trade.

Mr. T. G. FARDELL considered there was a certain amount of inconvenience in such an important matter coming upon them so suddenly. He only received a copy of the letter that morning, and there was nothing on the face of it to indicate that it would come up for consideration that afternoon. But after the very lucid statement of the chairman of the committee, he did not at all desire to oppose the letter as a whole, because he entirely agrees with him. But there was one important paragraph which he trusted the Council would not approve. It was that which said:—"With reference to clause 55 of the London Company's order which would enable the company to supply electricity to a vestry or district board for the latter to retail to consumers, the Council considers the expediency of granting such a power to be doubtful, and would suggest, that, if allowed, a provision should be inserted that the power given by the clause shall in no case be acted upon without the consent of the Council having been first obtained." That might possibly be the opinion of some members of the Council, but he would remind them that Major Marindin in his report specially alluded to the vestries, one of which had in view the taking up and the supplying of electric lighting in its own district. He did not think it was altogether fair that before the Council had had an opportunity of knowing what was going to be done that they should put in such a hampering clause which might completely stop what was intended to be done by certain parishes. At the same time, when their scheme was a little more matured, it would be perfectly easy for the Council to make a suggestion that such a clause or such an arrangement should not be insisted upon. He therefore asked the committee if they would allow that particular clause to come out; and then he would support the rest of the letter.

Sir T. H. FARRER, Bart., replied that unfortunately the Board of Trade were very anxious to get this letter, because without it they could not go on with the order. If it were not for that, it would be very desirable that the Council should have a longer time to consider this matter. He did not see how the Board of Trade was to go on with the order, considering the period of the session, and nothing could be done unless they obtained the opinion of this Council. He had read this letter very carefully. His knowledge on this subject was greater two or three years ago than now; but still he remembered something of the trouble they had when Mr. Chamberlain's Act was passed. He (the speaker) knew enough to say that this letter had been prepared with the very greatest care, and he believed that it met all, or almost all, the points the Board of Trade wished to have before them. With reference to what had been mentioned as to the terms of purchase, he thought that such terms of purchase were provided for by the Act. Those terms the Council had nothing whatever to do with, and, if he remembered aright, the terms would not depend upon the dividends paid or the price of the shares on the Stock Exchange. But the whole of the property was to be valued, he supposed, probably upon the price at which it would be put down, and upon those terms it was to be purchased. He thought he was right in that, and if so, the objection fell to the ground. Then as regarded what Mr. Fardell had pointed out, they did not know whether London was to be supplied by one or many companies. It must become a municipal and not a vestry concern; and therefore it was desirable that they, as representing the whole of London, should have the controlling voice. Those were the chief objections which had been made, and he would therefore strongly urge the Council to adopt at once this letter which the committee had so carefully prepared.

Mr. JOHN TORR objected to giving too much powers to the Board of Trade in this matter. He thought that most of them when before their constituents committed themselves to this principle, that as far as possible the functions of the Imperial Government at present in London should be transferred to a directly elected representative body such as this Council. Therefore, instead of constituting the Board of Trade the authority in this matter of electric lighting, he thought the Supreme Court of Appeal should be as soon as possible transferred to the London County Council, with power to deal with this matter of electric lighting. In the second place he hoped that the proposal of Mr. Fardell's, that the vestries should have an independent power distinct from the London County Council, would not be accepted. It was very important that there should be only one power for water, markets, gas and lighting; and to give independent powers to local vestries which were altogether independent of the central body, would be to defeat the very object for which they were sent here to the Council. He trusted that the letter would be adopted in its entirety.

Mr. T. B. WESTACOTT wanted to point out that the clause alluded to by Mr. Fardell had really no bearing in the direction he supposes. It was said that by the enquiry taking place Paddington and another parish had been exempted from bringing electric light into their parishes. But they had not been exempted. With reference to this clause 55, what the Highways Committee wished to avoid was this—that if a vestry or district like Paddington desired to supply electricity in its own parish, and supposing they desired to get it from another company, and it would have to be carried into their parish, they should not be allowed to do so without the consent of the County Council who were the controlling authority. Therefore the point raised by Mr. Fardell would not be affected by this clause. He (Mr. Westacott) hoped the Council would adopt the letter which had been so carefully considered and drawn up by the Highways Committee. Complaint had been made that the matter had been brought up at the last moment. But the committee had only had it before them about a fortnight, and the Board of Trade had requested that a letter might be sent them in the course of this week, and if the Council did not agree to the communication to-day it simply meant that there must be delays in these electric lighting schemes.

Mr. HAGGIS, in reply, said: With regard to the question of Mr. Clarke as to the Council being the representative authority for the whole of the Metropolis, I think that would be met, if we inserted the word "county" instead of the City of London. Then, with regard to the question of Mr. Fardell, the Act distinctly says that we shall not have to pay more than the value of the plant at the time of purchase, and that we shall not have to take into consideration the goodwill or profit made by the company at all. No consideration of the profit or goodwill is to enter into the purchase.

Therefore that point is very clear indeed. Mr. Westacott has replied to Mr. Fardell's question as to the vestries. Then, with regard to the remark made by one gentleman as to the wording of the letter——

The CHAIRMAN: That is as to the verbal alterations.

Mr. HAGGIS: I do not know exactly what they are, but they can be made, if necessary.

The CHAIRMAN: They are worthy of Mr. Haggis's attention, and perhaps the Council will authorise him to make any verbal alterations in the letter that are necessary. (Cries of "Agreed, agreed").

The recommendation of the committee that the letter be sent to Board of Trade was then approved.

PROCEEDINGS OF SOCIETIES.

The Institution of Electrical Engineers.—May 23rd, 1889.

"Alternate Current Working," by W. M. MORDEY.

(Continued from page 671.)

I now wish to describe a method by which the amount of loss due to each of the two causes may be ascertained experimentally in the workshop on a practical scale. It is a very simple one, although not, perhaps, capable in all cases of the highest scientific accuracy.

(*a*). First run the dynamo on open circuit at various speeds (two readings will suffice), with the fields unexcited, or, better still, entirely absent, and measure the power absorbed in friction. Plot this value to any suitable scale, as O M in fig. 3, the ordinates representing horse-power, while the abscissæ represent revolutions per minute.

[redacted]

FIG. 3.

In the figure the mechanical friction being a quantity with which in this investigation we are not directly concerned, is plotted below the base line, O M′, in order that the other losses may be more clearly seen.

(*b*) Next run again on open armature circuit with the brushes removed, and the field normally excited, and measure the power absorbed. This will be the total power dissipated in friction, hysteresis, and eddy currents, if any, and must be plotted as O N. Then the ordinates lying between O N and O M′ represent the sum of the losses due to hysteresis and eddy currents, and somewhere between O M′ and O N must lie a line, O P, separating the hysteresis from the eddy currents.

We desire to find the position of this line. The difference between the rate of increase of the electric and magnetic losses enables us to separate them from each other. It may be taken that, with any given constant excitation, the loss from hysteresis is directly proportional to speed, within certain limits to be hereafter stated. The resistance (that of the iron) being constant, the eddy currents must vary as the first power of the speed, and the loss therefrom as the square of the speed.*

It will now be seen that it is easy to separate the values which are directly proportional from those which are proportional to the square of the speed.

Prof. S. P. Thompson, to whom I submitted this method, has kindly given me the following concise formulæ for finding the quantities:—

P and P_1 are respectively the combined magnetic and electric losses at the speeds S and S_1.

k = magnetic loss;

k_1 = electric loss;

$$k = \frac{P_1 S^2 - P S_1^2}{S^2 S_1 - S S_1^2};$$

$$k_1 = \frac{P S_1 - P_1 S}{S^2 S_1 - S S_1^2}.$$

Then, at any speed n,

Hysteresis = $k n$;

Eddies = $k_1 n^2$.

If armature cores are run in an excited field before winding, it can be determined to what extent their lamination is satisfactory, and whether the iron is of good quality; and then, after winding the armature conductors, another test shows what the additional increase in the loss is, and separates the effects of eddy currents in the core from those in the conductor, and the hysteresis from both. The method may also be useful to investigate the losses in the cores of armatures of different types, or differently built up, as, for instance, with iron wire or iron sheets.

This method has a useful application in rendering it possible to separate not only the magnetic loss from the electric loss in the iron, but to determine the waste by eddies in the copper winding of armatures.

It is usually entirely a matter of opinion as to how much of the power absorbed in running an armature on open circuit is due to any of the various causes referred to; and now that it is customary to wind armatures with heavy conductors, it becomes very desirable to be able to find in any particular case what proportion of the loss is in the copper, and what in the iron.

In fig. 3 are shown some results obtained with a four-pole (direct current) Victoria dynamo run at various speeds up to 1,200 revolutions per minute, with constant excitation. Power readings were taken by means of a White's transmission dynamometer, constructed by the Brush Corporation for the purpose of testing dynamos; and the H.P. absorbed in mechanical friction in dynamo, belt, and dynamometer was subtracted from the power spent electrically and magnetically.

To reduced errors in the dynamometer readings the dynamo was fitted with two pulleys, one twice the diameter of the other. This allowed of the dynamometer being run at the same speed, while two different speeds of the dynamo were obtained by changing the belt from one pulley to the other. Readings were taken at four speeds, viz., 450, 600, 900, and 1,200 revolutions per minute, corresponding to 15, 20, 30, and 40 ∿ per second. The position of O, P was readily found by "trial and error," this being a shorter process for a concrete instance than the application of the general formulæ. The assumption on which this method of testing is based was found to be correct up to 900 revolutions. The reading at the higher speed of 1,200 revolutions, or 40 ∿, shows that disturbing influences began to affect the results by reducing the rate of increase of the losses. The continuation of the curve O, N in a full line shows the actual loss; while the continuation in a dotted line, which is a parabola on O P as an abscissa, shows what the loss would be if the rate of increase holding for low speeds were maintained.

This shows that this method is perfectly applicable to ordinary direct current machines—for instance, to two-pole dynamos up to 1,800 revolutions per minute, or 30 ∿ per second—but that it is less useful for alternators.

The disturbing causes are probably rather complicated. They may be due partly to self-induction in the circuits of the eddy-currents, to lower magnetisation (although this effect, if present, is very slight, as was shown by the E.M.F. being almost perfectly proportional to speed), and to vibration. "Viscous hysteresis," if it exists, will raise the magnetic loss. There may be such an effect, in spite of the lowering of the curve, but it cannot be recognised, on account of the unknown variation of the eddies, at the higher speed. Iron cored alternators working at high periodicities may be tested in the following way, which will give some approach to correct results:—Let the test be taken at a low speed (not more than 30 ∿). This will give the hysteresis per period, and the eddies at that speed. Then, if at any higher speed the E.M.F. is proportional to speed, it may be assumed that the magnetic induction is the same as before, and the hysteresis per period will at any rate not be less than at the lower speed. It may be more. The difference between the calculated hysteresis, O, P, and the ascertained total loss, O, N, will be the eddies; or, if viscous hysteresis is a fact, it will be extra loss due to viscosity plus that due to eddies.

Heating of the armature core, and consequent increase of the resistance of the iron, is not responsible for the bending down of the curve O, N, in fig. 3 (although it would have that effect under ordinary circumstances), as the experiments did not occupy sufficient time to allow of any sensible rise of temperature. The effect is probably very complex and obscure, but it is one that well deserves study, on account of its present industrial importance.

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* Prof. Thomson's "Dynamo-Electric Machinery." 3rd Edition, p. 102.

It should be stated that the dissipation of energy (which has been spoken of as being in the armature) may be partly in the field magnets. This was, however, not the case in the experiments referred to. The conditions necessary for the prevention or reduction of eddies in the iron of field magnets are now pretty generally understood,[*] but it should be observed that it is not by any means as easy to check such waste in alternators as in ordinary dynamos. It is both better and easier to prevent than to cure them.

If a good transmission dynamometer is not available, results almost, or perhaps quite, as good may be obtained by running the machine at various speeds by means of an electric motor, and measuring the power required by the motor—first with the fields of the machine unexcited, to get the mechanical friction, and then with the fields excited, to get the total loss. The motor should then be run alone, to find what is absorbed in driving it at various speeds. The increase in watts over these last values, with the internal losses in the motor conductors calculated out and subtracted, will give, with a very fair degree of accuracy, the energy dissipated in the machine under test.

The upper curve, O N′, was plotted from readings taken after the armature was wound, and the difference in the ordinates between O N and O N′ shows the eddy-current loss in the copper conductor at various speeds. This loss, like that of the eddy-currents in the iron, rises as the square of the speed up to 900 revolutions, or 30 ∿, above which it rises rather less quickly. The full line O N shows the actual loss, the dotted line above it showing what it would be if the rate of increase were maintained. The difference is no doubt due to self-induction.

That the effect of self-induction is not noticeable unless the eddy-currents are considerable is in accordance with experiments that I published some years ago in connection with the Brush dynamo.[†] The results then obtained are shown in fig. 4. The straight line connects speed and the potential difference at the terminals with the laminated armature; the lower and slightly curved line shows the potential difference with the old form of cast-iron armature, which had only coarse divisions, scarcely meriting the term "lamination." The curve shows that the E.M.F. rose less quickly than the speed on account of the serious generation of eddy-currents.

FIG. 4.

In the laminated armature, although, of course, there were still eddies, their effect was not sufficient to cause any bending down of the E.M.F. line at any practicable speed of driving.

Coming now to an examination of the results obtained in the experiments, and shown in fig. 3, we see that the hysteresis loss in this particular dynamo—which I should mention is capable of working continuously with a normal load of 18,000 watts—was 0·195 H.P. at 450 revolutions, and 0·39 H.P. at 900 revolutions, the latter corresponding to 30 ∿ per second.

The magnetisation[‡] was about 12,300 C.G.S. lines—not by any means a high density. The armature had a long core, nearly square in cross-section, of 12 sq. in. area, and contained 615 cub. in., or 10,086 cub. centim. of iron strip 0·012 in. thick (No. 30 B.W.G.) separated by paper. This is a degree of lamination beyond which it is inconvenient to go. The peripheral portion was wound with this iron in parallel bands ½ in. wide, in order to reduce eddies caused by lines entering the periphery. The main inner portion of the core was of wider strip.

We find from the figures that the loss in hysteresis at 900 revolutions was as follows:—

0·39 H.P. = 291 watts = 0·473 watts per cub. in., or 0·029 watts per cub. centim. As the periodicity was 30, the dissipation of energy per complete period per cubic centim. was 9,613 ergs, or 0·001 watts, nearly.

It is interesting to compare this result, obtained in what may seem a rather crude manner, with the values given in the papers referred to. Prof. Ewing says (*Phil. Trans.*, p. 553) ". . . the double reversal of a strong condition of magnetism in soft iron involves the expenditure of about 10,000 ergs per cubic centim." He gives the energy as 9,300 ergs, with a magnetisation of 13,190 in very soft annealed iron. Dr. Hopkinson gives 13,356 ergs, with a magnetisation of 18,250.

Much, of course, depends upon the quality and hardness of the iron, but my results come out very close to those of Prof. Ewing and Dr. Hopkinson. This may be taken as proving the method capable of considerable accuracy. The eddies in the iron, it will be seen, are by no means to be neglected, even with the very fine subdivision that was used.

The eddies in the conductor are rather greater than usual, as the armature, being intended for a very low speed, had a larger amount of copper on it than usual.

The bearing of these curves on iron-cored alternators and on open circuit working generally is obvious. With a magnetisation of 12,000, the loss in hysteresis alone, at 100 ∿, would be over 1·5 watts per cubic inch of iron core, and the eddies would amount to a good deal more. I will only add that the eddies, both in the iron and in the copper, are greatest when no external work is being done, as was the case in my experiments. They are reduced by the effects of self-induction when the circuit is closed. A difference exists in this respect between generators and motors, a difference in favour of generators.[*]

I will not further extend this paper by dealing at a greater length with this part of the subject.

APPENDIX.

Extract from remarks by Mr. Mordey in the discussion on Mr. Kapp's paper on "Alternate Current Machinery."—*Proc. Inst. C.E.*, March 5th, 1889.

"Alternators might be divided into two classes, those which had iron in the armatures, and those which had not. As his own machine, made by the Brush Corporation, and that of Ferranti were the only examples of the latter class described by the author, he might be permitted to mention the reasons which had led him to avoid the use of iron. He thought the makers of dynamos would agree that almost all the ills that the dynamo was heir to were due to the presence of the iron in the armature. Its use in direct current machines might be said to be a necessary evil, as, although attempts had been made to do without it, all successful types of such machines required it for structural purposes. Iron in armatures when worked at a high magnetic density, and with rapid reversals or variations of magnetisms, became heated and wasted a good deal of power. In alternators this objection applied with very much greater force than in direct current machines, for in the latter the reversals of magnetism were comparatively slow. Thus the first result arrived at in quite recent practice is that the magnetic density that can be used in iron-cored alternators must only be about one-half that employed in continuous current armatures. This alone meant a considerable increase in the size of armatures, without any gain in output or efficiency. Although the loss per cubic inch was reduced by decreasing the magnetic density, the armature had to be made larger to compensate for it, and the total loss was actually increased, not reduced. Iron was used to reduce the magnetic resistance, to afford mechanical support, and to introduce self-induction into the circuit. The latter, an evil in itself, was said to be a modern necessity, caused by the convenience of working alternators parallel. Self-induction, for this or any other purpose, had probably not entered the minds of most designers at the time they first produced their machines, except, perhaps, as an objectionable feature, which they could not get rid of; but now it was being brought forward as an advantage. If iron was indispensable for this purpose, which he was not prepared to admit, it could readily be inserted in some part of the circuit where ample space and cooling surface could be provided, and from which it could be easily removed when not required, that was when it was only necessary to run one machine. The armature was the very worst place to put the iron, for there its presence was the most objectionable, and it was there least under control. Referring to the magnetic resistance of armatures, it would be seen that there were broadly two ways of arranging the armature coils and the field poles. The poles could be arranged north and south, facing one another, the armature coils having their axes parallel to the lines of force; or the poles could be arranged in successive order round an iron ring or drum armature core, on which the armature coils were wound or placed. If iron cores were used in the former case, the output would be only about one-half of what was obtained with air cores, on account of the necessity to work with reduced magnetic density, while at the same time magnetic and electric disturbances would be set up, both in the armature and field, wasting power, causing objectionable heating, necessitating lamination of the fields, and demanding an increase in the exciting power. These reasons were sufficient to explain why he had not used iron cores; but there were others. Magnetic resistance, between pole and pole, was made up partly of the necessary clearance space, partly in most cases of the space occupied by the copper conductors, and partly of the iron or other core. Now, if in air-cored armatures the core could be so arranged, as was quite possible, and was done in his own machine, that it occupied no more space than was taken by twice the depth of the conductors in iron-cored armatures, it would be evident that the former gained instead of lost by the omission of iron. They gained not only in magnetic resistance, but in all the other points to which he had referred, and they had the very great advantage that there was nothing to limit the magnetic density at which they could be worked except the magnetic saturation of the field poles, the only losses to be met and provided for being the ordinary electrical losses in the conductor caused by the passage of the current, and a small waste by eddy currents in the conductors and supports. Such armatures had the further advantages that their self-induction was negligible, their power of self-regulation was very great, and that on open circuit or light load they ran very economically; whereas it was well known that, when iron cores were used, the losses under such circumstances were often very serious indeed. He thought it was quite unnecessary to use iron cores for the purpose of obtaining mechanical support for the armature winding. The holding and driving, with a very limited clearance, of an armature consisting of thin iron, separated by such unmechanical substances as paper, and overwound with copper wire, itself covered with cotton, and expanding and throwing out from the combined effects of heating and centrifugal action, was a problem that had never been very successfully solved in direct current machines, and was certainly to be avoided, if possible, under the still more onerous conditions obtaining in alternators, where the electrical pressure was usually much higher than in direct current machines, and in which, as the author showed, the maximum mechanical strain on the wires was greater. He ventured to think it was much the best to make the armature stationary as he had done. It then had only to resist the tangential drag of the field. He thought a great mistake was made in some alternators in using Pacinotti projections. In all cases there should be, as nearly as possible, a steady magnetic flux in the field. This could not be done if projections were used. The Zipernowsky and Parsons machines were faulty in this respect. It was impossible to tell, by inspection of the former, which was the armature and which the field. They seemed quite interchangeable, and this was of course not right. In these two machines it would be seen that the magnetic resistance varied very much, as the iron projections passed through the cycle. This necessarily led to losses in the field, the lamination of which recently introduced in the Zipernowsky machine showing that such losses must be serious. There was one other machine to which he wished to allude, and that was to him a very interesting machine indeed. He referred to the alternator shown and referred to by Prof. Forbes as in some respects a development of his alternator. In that machine Prof. Forbes used the form of field which he (Mr. Mordey) had in his alternator; but he used it in combination with a form of armature having, like the field, only one coil. He ventured to point out that, for a machine with an iron armature, that form of alternator had some advantages. The armature might be described as a Gramme ring with the copper inside and the iron outside. The magnetic flux was, or might be made, perfectly even, the air gap was very short, the magnetic resistance very low, and it followed that the excitation required was very small. The author had alluded to a very interesting and important matter, probably new to most people, as it certainly was to him, namely, that the armature conductors in alternators showed a tendency to heat much more than in the continuous current machines, but in this machine described by Prof. Forbes there was hardly any question of eddy currents in the armature conductor, as the coil was not swept by the lines of force. Further, it was evident that a very low current density could be used in the armature coil without sensibly affecting the size, cost, or output, and it was also clear that the insulation of the armature coil was a very simple matter Another good point was that neither the armature coil nor the field coil need be rotated. For a machine with an iron magnetic circuit he thought this was a very good one; and he had only one other remark to make about it, and that was that he had himself invented and patented it some time ago! It was, he thought, a natural development of his alternator. He was glad to find that Prof. Forbes had had the same idea, because that showed it to be a good one. Much had been said about the form of the wave yielded by alternators. He had some time ago made an experiment with the first of his machines, using the method described by Prof. Ayrton, and found that the curve was almost a sine curve. On the subject of the lag in transformers, to which Prof. Ayrton had also alluded, he might be allowed to mention that, in the discussion of another paper by the author, he had first stated the fact,* and had described a very simple experiment, showing that the primary and secondary currents reached their maxima and minima practically at the same time."

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[*] See numerous practical notes on this subject scattered through Prof. Thompson's "Dynamo-electric Machinery."

[†] *The Electrician*, October 2nd, 1885.

[‡] The use of the word "induction" in so many senses is apt to cause confusion. "Magnetisation" would perhaps be better than "induction," "magnetic induction," "density," "magnetic density," &c.

[*] *Phil. Mag.*, January, 1886, p. 26. "The Dynamo as a Generator and as a Motor."

MAY 30TH, 1889.

(*Authorised Abstracts of Discussions.*)

Before the discussion on Mr. Mordey's paper on "Alternate Current Working" was proceeded with, the author exhibited and described an automatic current regulator, arranged to work within ½ per cent. without "hunting," and also explained a model and drawings of his "single coil alternator."

During the week he had received letters, amongst others, from Lord Rayleigh, Prof. Ewing, and Mr. Zipernowsky, bearing on his paper, from which he now read extracts. Lord Rayleigh pointed out that in the *Phil. Mag.* for 1886, he had worked out the virtual resistances of conductors. He also thought the term "*frequency*" better than "*periodicity*."

Prof. EWING referred to the work lost in hysteresis, and Mr. ZIPERNOWSKY promised to forward his criticisms later on.

Prof. FORBES read some notes by Dr. HOPKINSON, who states that to obtain direct control in parallel working neither large self-induction nor small self-induction is essential, but the best control is exerted when $\frac{2\pi\gamma}{T} = r + R$, where γ = coefficient of self-induction, T = period, and $r + R$ is the resistance of armature and leads. If the resistance of the leads or feeders be considerable, parallel working is more difficult.

In his paper of November 13th, 1884, the case of putting generators giving different E.M.Fs. in parallel was shown to be feasible, and from the equations of § 3 the work done by the leading machine becomes zero when $\frac{2\pi\tau}{T} = \frac{\pi}{2}$ where $2\,T$ is the difference in time phase. Dr. Hopkinson also says that all the phenomena observed by Mr. Mordey could be predicted from his 1884 theory.

In a communication from Prof. ADAMS, read by Prof. S. P. THOMPSON, attention is directed to the South Foreland trials of 1884, and described in his paper read on November 13th of that year, in which many of the experiments mentioned in Mr. Mordey's paper were performed satisfactorily. He regarded Mr. Mordey's statement on page 4, that alternators with small self-induction and resistance "will best run parallel because they will be the best synchronising motors," as equivalent to "saying that tuning forks synchronise when in unison."

Reference was made to the beats shown by the synchronising lamp when one machine was running at half the speed of the other, and from acoustical analogues Prof. Adams thinks alternators will run as motors at speeds corresponding to fractions or multiples of that of the generator. He attributes the active cause of synchronising to self-induction, and considers that the groaning heard when the machines were switched parallel to confirm this view.

Major CARDEW, referring to the frequency at which the temperature of lamp filaments begin to follow the current, said that in experiments on signal flashes, about 10 changes per second could be clearly seen. The section on safety and safeguards seems to him to imply that the faults (*a*), (*b*), (*c*), (*d*), must occur simultaneously if a person is to receive a shock, but the speaker thought (*a*) and (*b*) may exist unknown to a person who accidentally or otherwise touches the secondary whilst making contact with earth. Earthing the secondary, though safe as regards shocks, might considerably increase fire risks.

Dr. FLEMING, speaking from information recently obtained in Milan, said there was no difference between the average life of lamps worked by direct or alternating currents. As a possible explanation of the observations on the periodicity which gives maximum efficiency, he suggested that for rapid changes the viscuous hysteresis was most important, whilst for slow ones the eddy currents penetrated further into the metal, thereby wasting more energy. He thought the Institution greatly indebted to Mr. Mordey for demonstrating successful parallel working without much self-induction or resistance, and pointed out that to work alternators parallel satisfactorily not only must the machines come into step, but they must do so promptly, and considerable stability must exist. These conditions may be satisfied by suitably shaping the field poles and armature coils, for on these the shape of the E.M.F. curve depends.

Mr. KAPP complimented the author on his valuable paper, not as a formality, but because it was one of the best ever brought before the society. In his remarks on the paper he thought it was not at all clear how the E.M.F. of a machine excited to give 1,000 volts rises to 1,500 when placed in parallel with one giving 2,000 volts, but according to his idea this was probably due to the armature current demagnetising the fields of the generator and magnetising those of the motor. He questioned whether the self-induction of the armature was insignificant, for when the field poles were central with the coils they would act as cores for the coils, which would therefore have considerable self-induction; this will vary with the relative positions of the magnet and armature, and tend to pull the machines into step.

Mr. SWINBURNE suggested, as a satisfactory test of parallel working, that the machines should be capable of being kept on full load without undue heating of the armatures. Referring to the word "synchronising" he thought its use in the paper rather ambiguous, for in some cases it related to "speed" and in others to "phase." As regards the efficiency of transformers working at different frequencies, he thought the comparison ought to be made on different transformers, each designed for the frequency under which it was tested. Under these conditions, and with 50-light transformers, increasing the frequency from 42 to 83, raises the efficiency from 92 to 93 per cent. when worked at full load all day, and from 60 to 62 per cent. when working at full load for two hours out of the 24. From some recent calculations he found the loss from eddy currents in direct current armatures to be unimportant when thin plates were used.

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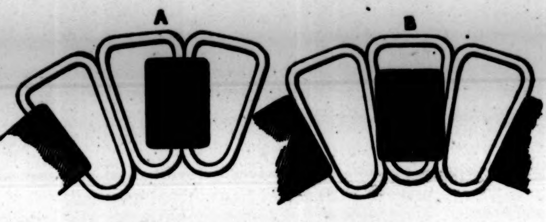
* *Journal*, vol. xvii., pp. 215, 216.

Prof. S. P. **Thompson**, speaking of arc lamps, announced that he had recently localised the back E.M.F. in direct current lamps, and found a sudden change in potential of 39 volts at the crater. He questioned Mr. Kapp's statement about the field magnets increasing the self-induction of the armature, for the time was too small (about $\frac{1}{300}$th second) to allow such masses of iron to change their magnetism in obedience to the armature current. Prof. Thompson also gave a graphical construction for showing the distribution of work between two machines of different voltage when switched in parallel.

Prof. **Ayrton** having obtained measurements of the self-induction of Mordey armatures by the secohmmeter, was in a position to say that neither Mr. Kapp or Dr. Thompson were quite correct, for the coefficient was 0·038 in position A (see fig.) and 0·036 in position B; and both decreased about 14 per cent. when the magnets were fully excited. The frequency of the testing currents was about 100 in all the tests. From experiments recently made at the Central Institution on the efficiency of the Mordey transformer, with frequencies varying from 53 to 240, he said there is no evidence of greater efficiency for medium frequency, on the contrary, the efficiency increases with the frequency, particularly for small loads, and is nearly the same for all frequencies at the maximum working load.



a, *a*, armature coils. *b*, *b*, field poles.

Prof. **Forbes** thought the fact of the engines driving the alternators when the experiments were made being ungoverned, should be clearly stated in the paper, for this helped considerably to explain the phenomena. He also believed Mr. Mordey was perpetuating an error if he assumed that only two methods of distribution were possible, either separate large machines, or small ones in parallel; but it was quite common in America to divide the mains and connect them to separate machines when necessary, and the circuits are so arranged that two or more may be switched on one machine during the hours of minimum demand.

The **President** (Sir W. Thomson) suggested the expression "*cophasedly synchronised,*" as meaning that the machines were in step both as regards phase and speed. To explain the result of coupling two alternators at 1,000 and 2,000 volts respectively, he considered the current resolved into two components differing by a quarter of a period and having their respective maxima at the positions A and B in the above fig. The latter component would tend to magnetise the motor fields and to demagnetise those of the generator, and in this way produce the observed phenomenon. Referring to the single coil alternator, he thought it a beautifully simple and ingenious machine, and though some loss would arise from magnetic friction, this need not be large.

Mr. **Raworth**, who during the week had made experiments on the E.M.F. curves of alternators and transformers, exhibited a diagram showing the arrangement adopted. The results, though incomplete, were, he said, astonishing, and he thought the question of lag would be settled in a manner not in accordance with theory.

Mr. **Mordey**, in reply, said Dr. Hopkinson's difficulty arising from the loss in leads was not a serious one, for the high potential used in transformer systems rendered any considerable loss unnecessary. Referring to Prof. Adams's criticism, he said he had laid no claim to the invention of parallel working, but had shown it to be perfectly practicable at a time when, in spite of the success obtained by Prof. Adams (to which he had drawn attention in his paper), considerable doubt existed as to its commercial possibility. He considered Dr. Fleming's explanation of the minimum generation of heat for mean periodicity a very probable one, and mentioned that although the heating at periodicity 125 was more than that at 100, yet the current passing through the transformer was less in the first case. As regards Mr. Kapp's difficulty, Mr. Mordey admitted that a change of 500 volts did occur, and although he had not attempted to explain the matter, yet the straight characteristic of the machine as a generator was a sufficient proof that as a motor the self-induction could not be large. Speaking of Mr. Swinburne's calculations on the loss due to eddy currents, he thought experiment far more satisfactory, and his observations showed the loss to be considerable. In reply to Prof. Ayrton, he said the method of determining the waste in transformers by direct currents was quite safe to use with fairly efficient converters. From Prof. Forbes's remarks, he thought his views on parallel working had been misunderstood, for he did not recommend it under all circumstances, but in cases where all the prime motors and alternators would work without requiring a large margin, it is a great convenience to arrange the leads and mains so that they may be connected in parallel.

"Hookham's Electricity Meter."

The inventor exhibited and described the working of his meter, details of which have appeared in the technical papers.

In the discussion which followed, the **President** asked what precautions were necessary to make the mercury contacts with the commutator satisfactory, and was informed that simple amalgamated line contacts were found suitable, and no appreciable resistance existed even after working many months.

Mr. **Crompton** said it was very difficult to make such meter register accurately for small currents, and in Mr. Hookham's instrument the error was very favourable to the supply company. In this he was corrected by the President and Mr. Hookham, the former of whom also pointed out that any error of this kind should be favourable to the consumer, for a few lamps more or less during the day load would make no appreciable difference to the coal bill of the producer.

Mr. S. **Joyce** concurred with Mr. Hookham as to the permanency of good magnets, for he had re-tested permanent magnet instruments after being in use six years, and had found them unaltered. He also enquired whether the meter could be tampered with by the consumer, and the inventor was understood to say that as the cover was sealed on this was impossible.

Mr. **Hookham** referred to a 100 ampèremeter, in which the motor was shunted by German silver, and the temperature effects tend to compensate each other. The process of making the permanent magnets was described, from which it appears that they are first magnetised and then weakened about 10 per cent., to give them a tendency to strengthen. The great secret of obtaining constancy was said to be making the magnetic circuit as nearly closed as possible, and instruments constructed on the plan described showed no appreciable variation after 18 months' work.

Physical Society, May 25th, 1889.

Prof. **Reinold**, President, in the Chair.

Mr. T. A. Lawson was elected a member.

The thanks of the Society were given to Mr. T. H. Blakesley for presenting to the library a copy of the second edition of his work on "Alternate Currents."

The following papers were read: "On a Water-Spray Influence Machine." By Mr. **George Fuller**. The apparatus is made up of four similar sections, each consisting of a nozzle, a metal ring, and a metal dish or receiver, arranged about a vertical axis. Pressure water issues from perforations $\frac{1}{100}$th inch in diameter in the nozzles, and passes through the ring into the insulated receiver below. The rings are placed at such a distance below the nozzles as to be about the point where the streams break into spray, and the receivers empty themselves automatically. Calling the consecutive sections 1, 2, 3, 4 respectively, the rings of 1 and 3 are connected to the receiver of 4, and those of 2 and 4 to the receiver of 1. The discharge points are connected with the receivers 2 and 3, and a rapid succession of sparks passes when the water is turned on.

Prof. S. P. **Thompson** enquired whether the length of the spark was limited by leakage along the glass rods or by the spray passing between the receivers, and in reply, Mr. **Fuller** said he thought the former leakage the most important.

"On the Molecular Weight of Caoutchouc and other Colloid Bodies," by Dr. J. H. **Gladstone**, F.R.S., and Mr. W. **Hibbert**, F.I.C. This paper gives the results of determinations made by Raoult's method, the reliability of which was first tested by preliminary experiments on substances of known molecular weights, and found to be fairly satisfactory. The experiments on caoutchouc give a very high value (above 6,000), thus confirming the author's previous impression that it was a colloid. Similar experiments were made on gum arabic, caramel, albumen, and ferric and aluminic hydrates, all of which were found to have high molecular weights. All the experiments confirm the belief that the molecule of a colloidal substance is an aggregate of a very great number of atoms.

CORRESPONDENCE.

Ocean Telegraphy.

In the **Electrical Review** of April 26th you devote more than a column to combat, for a second time, the contention in my first letter that iron armoured cables are being continually ruptured by the resilient action of the corroded wires. In this article you are pleased, with editorial urbanity, to charge me with "absolute ignorance."

I desire to call attention to a few dates. My letter, in which I adopted the "resilience" theory, was sent to you on the 28th February, and you were good enough to publish it on the 22nd March. You did not reply in that issue, but stated then that you would have much to say in reply in a future issue. After something short of a month to consider my argument, on the 5th April you replied to it.

If I understood your criticism, you studiously refrained from undertaking squarely to deny the alleged cause of the rupture of ocean cables. In a sort of way you admitted it. You were somewhat guarded and ambiguous, I concede, but you had not discovered my ignorance of how cables were made. You had not—had you?—discovered that I had "twisted" the cable? You (perhaps through *want of sufficient knowledge*) admitted that the "torsion produced by severing the wires" would naturally unlay to the disadvantage of the core. You concluded with the mild and courteous statement that you would leave your readers to judge how far the facts I stated went to prove anything in favour of hemp-covered cables, "only adding that it is not unusual to see a hemp rope behave in the same manner when similarly treated."

Not a word here about my "absolute ignorance," and no parade of your exhaustive knowledge as to the mode of making, coiling and properly paying out of cables. Twenty-one days afterwards, however, on the 26th of April, you boldly return to the subject. In the meantime, I suppose you will admit, your own knowledge of this crucial point in the discussion had been somewhat brushed up. Confess that you had improved the time in the great centre of knowledge on so all-important a phase of the subject.

Certainly you now, on the 26th, write with much greater confidence than formerly. You discuss with easy familiarity the subject of the manufacture, coiling, and paying out of iron-sheathed cables, and one not familiar with the subject would suppose your object in exposing my "absolute ignorance of how cables are made" was to cause it to be believed that the resilience of the wire was not the cause of the rupture of the core in the deep sea. Yet you do not say so. And I think you will not venture to say that. It seems to have satisfied you on the 26th—and I suppose it amused you—to have convinced your readers that your correspondent did not know how cables are made, or how they should be handled.

I desire to avoid side issues. I am only too willing, for the sake of argument, to admit as much ignorance as is compatible with a writer whose production is admitted into so respectable a journal as the REVIEW. I profess to know nothing more of how cables are made than an ordinary person of some industry, who has taken pains to study the evidence on that subject taken before the Joint Commission at Whitehall in 1859-60, and who has read what has been published of importance on the subject since, and who has also discussed the subject with those who have made and handled cables. I really could not undertake to make a cable; nor, I suppose, could you, although you, I think, pose a little too prominently as the champion of those who do make them.

This, if you will pardon me, is not the question; but the question is: "What is the cause of cables breaking in the ocean where there is no motion?" (It was from the famous Maury, and *not* in a lady's album, as you suggested, that I adopted the words that all was motionless in the deep solitude of the ocean). Do you or do you not deny when steel or iron wires become corroded, as you and those skilled in making them know they do sometimes in a few months, that by the recoil of the resilient wires they twist asunder the copper with the gutta-percha covering at the depth in the ocean of over two miles, and thus interrupt communication? I pause while you are considering that question, to suggest that such ruptures occur to the enormous loss of the telegraph companies, and the corresponding gain of the construction companies, to say nothing of the great inconvenience and expense to the public.

In the evidence before the Joint Commission it was clearly pointed out by some of the ablest experts, and denied, I think, by no one witness, that if the core with the enclosed copper wires could be once safely laid on the bed of the ocean, it was impossible to conceive of any cause of rupture, and that it would always remain in perfect working condition. It was then naturally overlooked that in the manufacture of a cable it was not possible to get each convolution of wire up against (to use your language) "its rigid neighbour" without storing up a fatal force, which, when released by corrosion in a particular spot, would (to again borrow your expression) "unlay the wires to the disadvantage of the core," or, in other words, cause a break and a consequent expenditure of from, say, £1,000 to £100,000 for repairs.

Will you pardon me for suggesting that both in your article of the 5th and the 26th April I detect some misapprehension in your mind on the subject of torsion. You state that wires are not "twisted" when applied as armour to the cable. No one, I suppose, ever imagined they were. I never supposed, and never said they were. What I contend is this, that since the date of the joint commission there has been made an important and valuable discovery for the public and for all except the people who advocate the cause of those who make the "serviceable article" you say you are "satisfied with." That discovery is this, namely, that resilient force in the helical lay of the wire does exist, and is stored up, so to speak, so that when the steel or iron wires of the cable as it is usually paid out, and as it lies at the bottom of the ocean become at any point corroded they suddenly sever or snap asunder, and by twisting or wringing the core rupture it. I contend that science aids us in coming to the conclusion that this is highly probable from the nature of the circumstances. And I further say that by the simple experiment of placing a length of iron-sheathed cable precisely to represent that which lies on the floor of the ocean and partially filing the wires, they will in turning in opposite directions on either side of the file twist the core to such an extent as to rupture and destroy it. You seem strangely and strongly averse to experiment and enquiry on this subject of ocean cables. The force which I describe could, I assure you, be practically proved, perhaps not altogether to your personal satisfaction, but yet so as to convince if not astonish you if you were to place your fingers—say, the thumb and two fingers with which you hold your incredulous pen—on a close-armoured cable whilst, say, three or four of the wires are cut. In such a predicament you would begin to apprehend to what resilient force allusion has been made, and why I am so persistently demanding enquiry.

I have referred to the unassailed opinion, that if a cable could once be laid down safely in the deep ocean, no conceivable danger could ever encompass it, and it would remain without the necessity of repairs to convey messages practically for all time to come. That, in so far as iron-sheathing was involved, was a delusion soon to be dispelled. It is now known—it has been admitted by scientific and practical men alike that iron-sheathed cables are not only extremely perishable, but that the iron wires are *the cause of their destruction*. You will not, I think, deny this. Will you *now* suggest how it is possible that the corrosion of the wire ruptures the core? How does the "slow burning" of the iron—the complete destruction of the outer sheathing interrupt communication? A large fleet of costly ships, expensively equipped, are constantly going out into the deep ocean at all times of the year to raise the broken cables and repair them. Why does the core break? Will you suggest the cause of the severing of the copper wire and the gutta percha covering. The core grows harder and improves in the ocean. No marine animals ever destroy it there, but when it comes up it is usually found freshly wrenched "short off."

If you will offer any explanation of this you will find hundreds ready to pay the most respectful attention.

I adopt the theory of those best qualified to know, and maintain that sufficient enquiry should be made to set the question at rest. You, without explaining the cause, admitting the case to be inexplicable, desire to prevent inquiry, and you argue that the public should be satisfied, as you are, with the "article" now so lavishly furnished. Do you not think you thus (to use again your own language) "give yourself away"?

I insist—not to be "fanatical" I suggest rather—that, minus the iron wires, the expert opinion given on the inquiry before the Commission was literally correct, namely, that the core safely laid in the ocean is practically indestructible; and no one can suggest any reason for ever apprehending a cause of rupture or injury—at any rate, in the Atlantic.

You admit a hempen cable can be made and laid. I think you do not dispute that it can be raised if it should ever require to be raised. You admit that it is cheaper and can be easier handled, which is a very great point in the expense. I observe by examining former discussion in the REVIEW, it was admitted that hemp is more durable than iron—that, in fact, it was indestructible. Was that uttered in "absolute ignorance"? It is true you have showed slight signs of a change of front on this last point recently, but you have given no reasons for such change. No new evidence has been furnished. On the contrary, have you not discreetly ignored my suggestion that it has been found that "Bright's compound," or some superior mixture, if possible, will render hemp impervious to the most destructive marine animals. As to your tiresome references to the failures long since to lay things called hempen cables when the subject was little understood, for every such failure were there not a score of failures to lay iron cables of which you also are silent?

You have raised some small side issues, and if it suits your disposition to persist in it, you have, if you like, to expose my ignorance in cable manufacture. What has all this to do with the main issue?

On this main issue of improved and cheap ocean telegraphy I am glad to see that we differ less than at first seemed to be the case. You say you are "slow." Very slow, I am afraid. I regret it. I would not have been so discourteous as to suggest what I strongly suspected if you had not made the frank admission. I am rather conservative myself. I think I might fairly insist that other great companies should follow the Anglo-American Company in their adoption of a hempen type of cable, but all I actually insist on is that no large sums should be spent for subsidising cables without further enquiry as to the superiority of hemp over iron for sheathing, an enquiry which may be extended to learn whether, in fact, an improved cable cannot be found through which almost the entire communication across the ocean spaces of the globe may be sent without waiting for the "slow" passage of the ocean mail bag.

Robt. L. Weatherbe.

Halifax, Nova Scotia, *May 27th*, 1889.

Electric Traction at Brussels.

The remarks contained in your article, "Cui Bono," of last week's "ELECTRICAL REVIEW" *re* the Julien patents, are, without doubt, true in every sense. I was in Brussels about the middle of April of the present year, and after riding upon, what I believed to be the Julien electric car, of which four were running in the Rue de la Loi, I had the opportunity of seeing the depôt and making a little investigation. Upon inquiry at the works I ascertained that Julien's motors were not used upon these cars at all. I saw four or five of them packed away in the further corner of the dynamo room, and was informed that the motor now employed was that of Elwell-Parker, of Wolverhampton, and that the storage cells now used were the Faure, Sellon, Volckmar, which I soon saw was the case.

The chain gearing, as described in Julien's patent, was not being used upon the cars, a chain of another make was employed instead. I was informed by one of the officials that their use had been discontinued for some time.

I came away considerably disappointed, because had heard so much of the successful working of Julie system.

If you had been acquainted with these facts yo could not have asked a more pointed question than yo have done, viz.: "Where does the traction system Julien come in?" and further, as you state that "T the best of your knowledge he has neither a motor n gearing to call his own," this is exactly the conclusi I came to after witnessing what I did at Brussels.

Ampère.

June 10th, 1889.

Alternating Current Motors.

Since a few months ago you kindly gave me t opportunity of republishing in your Journal the resu of researches on alternating current motors carried o at the works of Messrs. Siemens and Halske, in Berli I feel justified in begging to be allowed to offer throug your Journal a few remarks on the newest publicatio on this subject by Messrs. Ganz & Co., of Buda-Pest.

In the paper referred to, I gave a short account and geometrical treatment of Dr. Hopkinson's discovery o the possibility of running ordinary alternators a motors. I stated what was well known to everybody who had investigated the subject, that there was n reason why as good an efficiency should not be obtaine by such a motor as by a corresponding continuous current motor, but that the drawbacks to the use of such a motor lay in the necessity of synchronism. A synchronous motor can never be started with the load on, and must be designed for a load exceeding more or less considerably the load actually to be put on it, because it will always come to a standstill as soon as the load, from any reason whatever, reaches a certain maximum value. I am aware that I am repeating simple and well known facts, but if these facts are duly considered, nothing remains in Messrs. Ganz & Co.'s publications to interest the electrician who is acquainted with alternating current work, except the perseverance with which the authors reprint for the fifth time, if not oftener, an ordinary mistake of calculation, viz., in the last column of their table, headed "Commercial efficiency," "77" instead of 69·9, and the very curious leap, "0·88—0·77—0·92" in the column headed "ratio of watts actually consumed to apparent volt-ampères," which, if "measured in fact," as we are now assured, is not to the credit either of the measuring instrument, or of the electrician employed to read it. Since these three measurements are given as the result of four years labour, it is to be hoped that the real outcome of so much labour, which is rigidly kept secret in these publications, namely, Messrs. Ganz & Co.'s method of starting their alternators, may not turn out to be of a similar character.

A. du Bois-Reymond.

Berlin, *June 6th*, 1889.

Photography by the Aid of Lightning.

Enclosed herewith is a transparency that was produced on Thursday night, June 6th last, during the storm. A sensitive plate was placed behind a negative in a printing frame held near a window, and exposed to the light of three flashes, the plate was then developed and fixed. This is one out of several such photographs that I was enabled to produce during the night. It is, as you will see, a picture of my electric car.

A. J. Jarman.

June 12th, 1889.

[We thank our correspondent for this interesting and excellent specimen of the photographic art.—EDS. ELEC. REV.]